The Engineer

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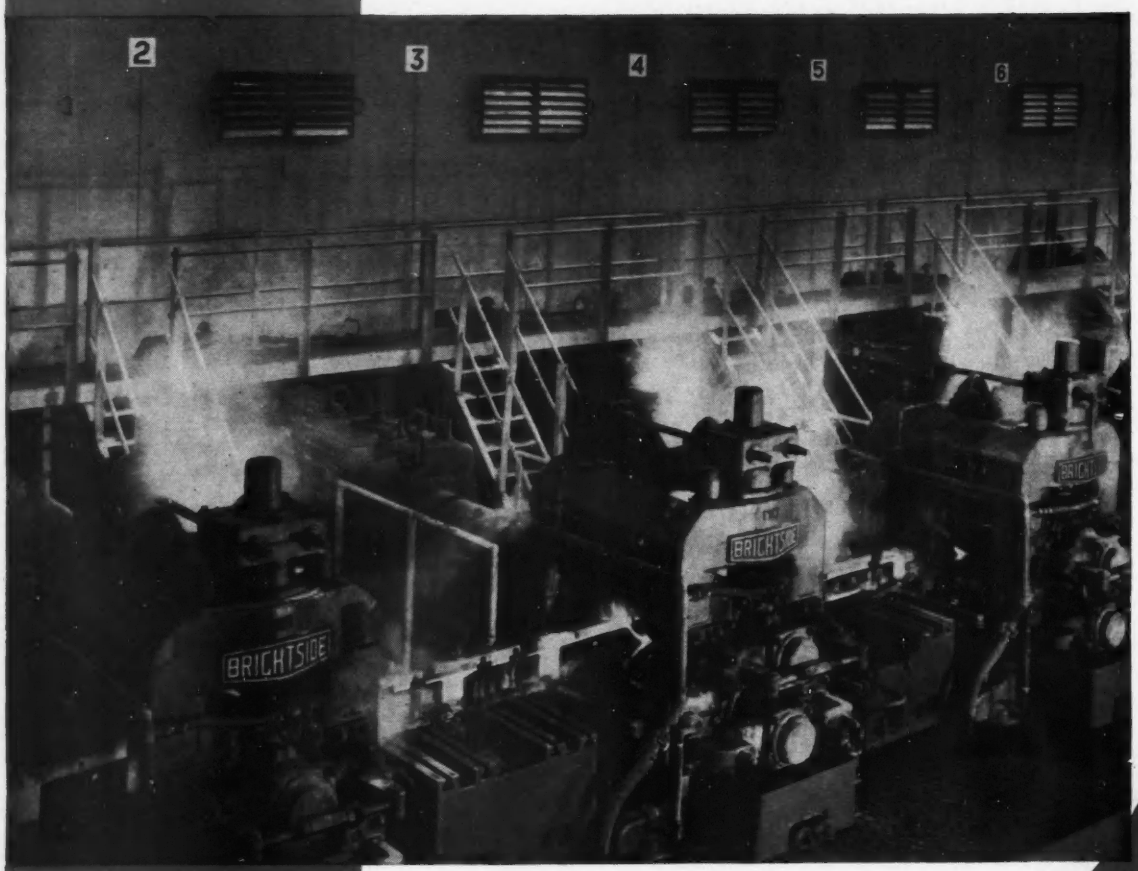

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THE ENGINEER

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RAILWAY PROSPECTS

It has been obvious over the last few years that, financially, the affairs of the British Transport Commission have been working towards a crisis. Up to 1954 it is true that the accounts had been kept roughly in balance. For an almost continual growth in the accumulated deficit could be accounted for by delays in getting increases of railway fares and charges approved by the Tribunal. Nevertheless they were thus kept roughly in balance only by raising fares and charges and these increases were tending to deflect traffics to other forms of transport. There was, indeed, a suggestion of the Rakes Progress about it all. Goodwill was being steadily lost, the more so that the freight services provided were often regarded by users as unsatisfactory in speed and safety. Matters came to a head earlier this year. For special reasons, the railway strike amongst them, 1955 proved a particularly adverse year in which the working surplus earned amounted to little more than half the central charges payable; and when the Government intervened to prevent further increases in fares and freights, with the object of helping to stabilise the cost of living, it became obvious that some action would have to be taken to support the Commission financially. For by the end of 1955 the accumulated deficit had already reached £70,000,000 and by the end of the present year it is unlikely to fall short of £120 million. This was a matter of deep concern to the Commission because a growing deficit of this nature must necessarily undermine financial discipline if nothing were done to counter it. What, railwaymen would tend to argue, would another million or so lost matter to an organisation already over £100 million in deficit and making a substantial additional deficit every year? For a similar reason the Commission, even had it been offered, would have been very unwilling to accept indefinitely any form of Government subsidy.

A White Paper issued last week indicates the answer to the problem that has been worked out between the Government and the Commission and which, in a form more specific than is defined in the White Paper, will be put before Parliament. The chief provision is that over a limited term of years and up to a total limited to some such figure as £250 million the Commission shall be empowered to borrow from the Consolidated Fund. The loan, upon which a commercial rate of interest will be payable, will be repaid by instalments beginning after the expiry of a specified period still to be laid down. What lies behind this arrangement is the conviction of the Commission that potentially its financial situation is strong and that it possesses in the railways an asset which when modernised will yield earnings fully capable of meeting all charges, interest on the capital expended and interest and repayment charges on the money borrowed. Present financial difficulties it is maintained are the inevitable consequence of twenty years of neglect in modernising the railways brought about first by the depression of the 'thirties, then by the running down of the asset during the war years and since then by severe limitation of capital expenditure by the Government. By vigorously pressing forward the present modernisation plan, it is confidently expected that the railways will become more economical to operate and will provide more attractive services. The White Paper examines the ways in which economies will be sought and makes estimates of the effects upon railway finances. The proposals include not only the modernisation of equipment but the modernisation of methods. Increased productivity is to be sought by mechanisation and through the use of work study and both these methods have already begun to yield results. In addition it is hoped that relief from certain statutory obligations will enable railway charges to become more competitive and that certain further reliefs will be granted. Under the estimates given in the White Paper, which are necessarily founded upon the assumption that costs will be stable and the value of the pound maintained, the accounts should be approximately in balance by 1961 or 1962; and by 1970 overall profits of about £50,000,000, it is expected, will be earned annually.

Is there any real hope that the policy can prove successful? Will the railways even when modernised really prove able to pay their way? On the one hand the more optimistic, in answering those

questions, will point out that because the industrial output of the country should rise substantially in coming years the traffics should be available for modernised railways to capture ; they will point, too, to the financial success of the Netherlands Railways which had to be almost entirely rebuilt and re-equipped after their destruction during the war ; and they will add that even after the present modernisation plans have been carried to completion there will still be plenty more to do in seeking further economies. Pessimists on the other hand will note that estimates in the White Paper do not appear to allow for the possibility that road hauliers may economise in their costs and speed their deliveries. For unquestionably under the growing weight of criticism the Government will soon have to give way and begin to spend large sums of money on modernising the roads, building motor-ways and improving road access to urban areas. The justification for the expenditure involved would lie in the reduction of road transport costs. Both optimists and pessimists, however, must applaud the Commission's desire to reject any form of subsidy and every engineer will hope that the railways can be put on a sound financial footing. A General heads the Commission. Military experience has no doubt taught him the importance of maintaining morale. The acceptance of a subsidy would have been an admission of defeat.

TO SKID OR NOT TO SKID

The Institution of Civil Engineers last week heard a somewhat disturbing address, which merits the closest scrutiny by road transport engineers. It was delivered by Mr. C. G. Grimes on the subject of the skidding resistance of roads. Mr. Grimes has been concerned in a great deal of research on the nature of the skidding motion, and it is not, therefore, surprising that an apprehensive interest has been aroused by, for instance, his treatment of braking requirements : "The provision of a sufficiently high skidding resistance to meet the maximum performance of the modern car when braking in wet conditions presents a virtually insoluble problem for the highway engineer. Wheels can be locked quite readily on dry surfaces, and to attain the shortest braking distances of which vehicles are capable, as when making emergency stops, a maximum deceleration approaching $1 \cdot 0\,g$ is required. For this to be possible, a coefficient approaching 1·0 is needed and on dry surfaces coefficients may be as high as 0·8 even at speeds up to 100 m.p.h. (C. G. Giles and F. T. W. Lander, 'The skid-resisting properties of wet surfaces at high speeds,' *Journal of the Royal Aeronautical Society, Vol.* 60, (February 1956)). Thus, in braking performance, the modern vehicle is certainly able to utilise the highest coefficient likely to be obtained ; even these are not likely to prevent wheels from locking and skidding when the maximum braking effort is applied in an emergency."

The coefficients referred to are, of course, those for a wheel in the skidding condition. The previous work of Mr. Giles was done with a lockable wheel towed by a fast car along aerodrome runways, and showed that the coefficient of sliding friction, while barely affected by speed in the dry condition, diminished, albeit more and more gradually, as relative speed rose to 100 m.p.h. in the presence of a film of water. The measurements on roads used in the present paper were taken by the "sideway force" method with a slip angle of 20 deg. which, except possibly to a racing driver, represents a skid. The extract above shows that Mr. Giles relates resistance to skidding with these figures of skidding resistance. A statistical demonstration that this is so—i.e. presumably, that the shape of the friction/velocity curve does not vary radically—occupies a large part of the paper. The statistical study includes many figures for the accelerations actually experienced by road-going vehicles, but unfortunately observations were not made on roads of known skidding resistance. Thus one cannot infer how many vehicles experienced accelerations greater than the skidding resistance and were in a condition to encounter break-away. Mr. Grimes is, perhaps, sugaring the pill offered to the road engineers when he suggests that vehicles will not call for accelerations exceeding 1 *g*. This, while it is certainly borne out by his statistical analysis of to-day's traffic, is hardly a safe assumption when discussing the minority of vehicles capable of attaining 100 m.p.h. The "Manx" Norton —the racing motor-cycle — commonly exceeds its designed maximum bank of 45 deg., as is shown by flats ground on megaphones, for instance, and, lacking perfect instantaneous balance between front and rear wheels, a high performance car may well call for single wheel brake reactions exceeding the applied weight. The question of how much "stiction" is available is, of course, an exceedingly troubled one: Mr. Giles's runway experiments suggest that the difference between static and sliding coefficients is large, but his apparatus does not allow the contribution of the inertia of his rolling wheel to the "initial kick" to be estimated.

This present report, showing how low skidding resistance is, compared with the accelerations used in manœuvres, carries an important moral. Mr. Grimes advocates increasing the skidding resistance of the road, having shown that skids are infrequent where the skidding resistance exceeds 0·4, and this course has the great advantage that it shortens the trajectory of the skidding vehicles. But, since the paper brings out clearly that skidding resistance is severely limited in wet conditions, it is most important that road builders should remember that the prime necessity is to avoid a skid, and should take extreme care to suppress any small-scale irregularities of surface that precipitate wheel-spin or sliding. Meanwhile, operators will certainly be reinforced by this paper in their demand for reduced unsprung weight, for better compensated brakes, and for tyres with a greater grip; and we hope that engineers will undertake the development of an acceleration-sensitive anti-skid braking system. A possible approach to this problem can already be discerned in the electric braking system associated, in this country, with trailer caravans. There would be a very direct and, if Mr. Giles's accident figures are to be believed, beneficial application to the solo motor-cycle.

The Engineer
100 Years Ago
(OCTOBER 31, 1856)

"HOSTILITY OF CERTAIN ENGINEERS TO THE PRESS"

"The follies and prejudices of the higher classes seem to have a natural proclivity to the lower end of the social scale. The fashionable oaths, the drinking usages, and even the formal manners of the nobleman of a former age, in common with his laced coat, cocked hat, and ruffles, have descended to the flunkeys and beadles of our day. A somewhat analogous declension has befallen the hostility to the press evinced by our rulers in the 'olden time,' when an officious printer of the speeches in Parliament incurred the risk of having his ears cropped in the pillory. As the force of public opinion began to render further intolerance of this kind impracticable, it became the distinguished foible of the military servants of the Crown, with whom the press has always been a bugbear of the first magnitude. More recently the prejudice has fallen to the lot of a certain class of engineers, who seem inclined to cherish the weakness as one which still retains some flavour of its aristocratic origin.

"That this absurdity is destined to remain for any length of time among men of such liberal views and general intelligence, we refuse to believe. . . . Whenever a body of men succeed in isolating themselves from the influence of public opinion, they inevitably surround themselves with an atmosphere of egotism, as foul and unwholesome as their own breathings. . . . We can readily believe that men who are constantly engaged with the details of an extensive practice can have but little time to spare for writing, nor is it in all cases very desirable that such men should write, their work is often of much greater value to the public than anything they are likely to indite for its benefit. What we complain of is, that those who do not write seem to imagine themselves aggrieved by those who do. The engineer who ventures to give publicity to his opinions, is supposed somehow to have exalted himself at the expense of his neighbours—to have sought a notoriety to which he was not fairly entitled. The writing man is held to be dangerous, not because he discusses the principles of his art, but because he may disclose those whose secrets of trade policy do not appear to advantage in the daylight of public opinion."

A Seven Day Journal

Scientific and Engineering Manpower

AT the end of last week, there was published as a White Paper a report on scientific and engineering manpower in Great Britain, which has been prepared by the Ministry of Labour and the Advisory Council on Scientific Policy. This report says that the Council's scientific manpower committee has estimated that at least 85,000 more qualified scientists and engineers will be required in the next ten years, representing an increase of 63 per cent over the numbers employed to-day. The committee considers that the aim must be to increase the annual output of scientists and engineers by over 60 per cent by 1966 and 100 per cent by 1970. This, the report says, is a statement of a minimum goal which needs to be achieved if the economy is to grow at an acceptable rate. If the universities and technical colleges can achieve more, it is added, so much the better. The report includes the results of inquiries which have been made by the Ministry of Labour and by the scientific manpower committee of the Advisory Council on Scientific Policy. The Ministry's inquiry was concentrated upon the present numbers and distribution of scientists and engineers, and the demands of industry and "other main users" of scientific manpower in three years' time. One conclusion reached was that, of the 135,000 qualified scientists and engineers employed in manufacturing industry, about 45 per cent were shown to be engaged in research and development, 47 per cent in production maintenance and installation, and 8 per cent in "other work." The scientific manpower committee's investigation was concerned with the likely trend in the long-term demands for scientists and engineers. Its estimate has already been mentioned. Another conclusion arrived at by the committee is that there is "little risk" that the greatest possible combined efforts of the universities and technical colleges will result in any over-production of professional scientists and engineers during the 1960s.

Proposal for a Fully Automatic Multi-Storey Garage

A WORKING model of a design of multi-storey garage known as the "Rotapark," was shown to the press this week by the firm of contractors, Griggs and Son, Ltd. A ten-storey version of this design would be capable of accommodating 350 cars (thirty-two on each floor plus thirty on the ground floor "reservoir"), and would occupy a site of about 100ft by 100ft. It would consist of four lifts, each to take one car, arranged in a cross, at the centre of the circular building. Cars would enter and leave the lifts in a radial direction; at each floor there would be a "parking rotor"—a ring of thirty-two "stalls" for parked cars, which could be rotated so that any one stall could face a lift, with a turntable on the ground floor where cars were driven in and out. Thus in operation the parking rotor on each floor would oscillate in a 90 deg. arc, with each lift serving eight stalls. A parking dolly, which travels under, and holds, the front wheels of the car, moves it on and off the lift. In operation, a car would be driven on to the turntable and left with its brakes off; its parked stall would be chosen and recorded by a perforated disc, given to the owner. All subsequent operations would be automatic, and initiated by inserting the disc in a machine in the central office. The average time to park a car would be fifty-three seconds, so with the four lifts, about four cars a minute could be handled. The "dolly" would be able to handle practically all cars, but unusually large cars or three-wheeled cars would be parked in the ground floor "reservoir," which would also permit flexibility of operation generally. It is claimed that a "Rotapark" building will give parking space at a cost of £450 to £500 per car, as compared with £700 to £1200 per car for "ramped" multi-storey garages where the cars are driven in and out. The automatic control also gives economy of operation. The "Rotapark" is expected to supplement parking meters, finding its main application in the central areas of large cities. Two schemes are at present envisaged in the City of London—one at Aldersgate and one in Queen Street, close to Blackfriars Bridge—and will be proceeded with, we understand, when all the planning consents have been completed.

Convention on Ferrites

AN international convention on ferrites, organised by the Institution of Electrical Engineers, is being held this week in the Institution's lecture theatre, Savoy Place, London, W.C.2. The proceedings opened on Monday, October 29th, under the chairmanship of the president, Sir Gordon Radley, with an introductory lecture given by Dr. Willis Jackson. To set the scene for the fifty papers that were to be discussed at the convention, Dr. Willis Jackson began by reviewing the extent to which progress in electrical engineering was bound up with the improvement of well-established materials and the discovery and development of new ones. He cited a number of recent examples, including those of germanium and silicon, whose usefulness as semi-conductors or rectifiers depended upon methods of production whereby impurities could be limited to $1 : 10^7$. Turning to the ferrites, Dr. Willis Jackson explained that they could be represented by the general chemical formula MFe_2O_4, M being a divalent metal; and that their main interest to the electrical engineer lay in the fact that appropriate treatment and synthesis could endow them with exceptionally high resistivities (up to a million times that of ordinary iron) so that they could be used at the highest frequencies without incurring serious eddy-current losses. The lecturer went on to outline the relationship between the chemical compositions, physical structures and magnetic properties of different ferrites. He then explained the dependence of the saturation magnetisation, the initial permeability, and the frequency-variation of permeability on composition, for both single and double ferrites. He also referred to ferrite compositions having hysteresis loops of almost rectangular shape and to their suitability for use as storage elements in electronic computers. Subsequent sessions of the convention were devoted to chemical and physical properties and the preparation of ferrites, magnetic spectra and molecular interaction, d.c. and l.f. properties, radio and television applications, square loop materials and their applications, and microwave properties. To-day the final sessions of the convention will be concerned with carrier frequency applications and microwave apparatus. During the convention several groups of exhibits are being displayed in the Institution building to illustrate the properties of ferrites and some of the ways in which they can be used in radio, television and computer storage systems and in carrier frequency and microwave work.

Radioactive "Waste" for Deep Therapy in Great Britain

THE United Kingdom Atomic Energy Authority announced last week that radioactive "waste" recovered from atomic piles is about to go into large-scale use in British hospitals for the treatment of deep-seated cancer. A source of radioactivity consisting of caesium derived from the fission products of the Windscale pile has been delivered to the Royal Marsden Hospital, London, and has been installed in a specially designed therapy apparatus at Sutton, Surrey. This source has an activity of more than 1200 curies and is, therefore, equivalent to about 1200 grammes of radium. It consists of a caesium salt contained in a platinum capsule, 7cm long and 3cm diameter, surrounded by protective shielding consisting of lead and uranium, weighing about a ton. The gamma-rays emitted from the source are defined by a special form of shutter consisting of curved plates of tungsten alloy moving around the surface of a sphere, the source being shielded by uranium. During treatment both sides of the patient can be seen, one side being viewed directly through a window and the other through the medium of a closed-loop television system with projection on to a screen in the treatment room. This method of using caesium is based on a proposal made by Mr. W. S. Eastwood of the isotope division at Harwell; the large-scale extraction of caesium from highly radioactive waste liquors and its subsequent refinement and preparation was carried out at the U.K.A.E.A. Windscale Works, Cumberland.

London Airport Accident

THE Minister of Transport and Civil Aviation has invited Dr. A. G. Touch, of the Ministry of Supply, to inquire into certain aspects of the accident to an Avro "Vulcan" bomber at London Airport on October 1st. The report of an R.A.F. court of inquiry was furnished to the Secretary of State for Air on October 23rd, and he stated in a written answer in the House of Commons that there were points which called for investigation in the Ministry of Transport and Civil Aviation.

Alexander T. Bean

SELDOM, if indeed at all, during this journal's first century of publication have we had to record the decease of a centenarian engineer. Mr. Alexander Thomas Bean, who died at his home in London on October 22nd, had celebrated his 103rd birthday in August, and did not, we believe, retire from his consulting practice until he was over a hundred years old. Mr. Bean served as a premium pupil in the early 1870s with the well-known firm of Harvey and Co., at Hayle, Cornwall, and was there engaged in the building of Cornish engines. Subsequently, for many years, he was engaged in consulting work in Westminster, in partnership with Mr. Rogers Field. Mr. Bean had been a member of the Society of Engineers for fifty-three years. He was also an enthusiastic member of the Cornish Engines Preservation Society, and as recently as a month ago had written to that society, on the occasion of its annual meeting, expressing his continuing interest in its work.

Obituary

PHILIP VASSAR HUNTER, C.B.E.

In last week's issue we briefly recorded the death, on October 22nd, at "Springhurst," Shirley Church Road, Addington, Surrey, of Mr. P. V. Hunter, who was a leading personality in the electrical industry and made many outstanding contributions to cable development.

Philip Vassar Hunter was born at Hungate, Norfolk, in 1883 and was educated first at Wisbech Grammar School and then at Faraday House, where he obtained an honours diploma. The "sandwich system" at Faraday House provided the start of his practical training with the Rugby firm of Willans and Robinson. Further practical experience was gained with the electricity supply undertakings at Great Yarmouth and at Willesden. Then for a time he worked as assistant to Robert Hammond, the consulting engineer. In 1904 he joined Messrs Merz and McLellan and so began an association which lasted for fifteen years and brought him into contact first with power station development and then with railway electrification in various parts of the world. He was concerned, for example, with the design of the Carville and Dunston power stations and with several generating stations, using waste heat, in the North East of England. Still with Messrs. Merz and McLellan, he worked on the electrification of the Central Argentine Railway, the Buenos Aires Western Railway and the Melbourne Suburban Railways.

From 1909 to 1919 Mr. Hunter was head of the firm's electrical department, but in 1917 his services were placed at the disposal of the Admiralty and he was appointed engineering director of the Experiments and Research Section of the Anti-Submarine Division. There he collaborated with Admiral W. W. Fisher and Sir William Bragg on a three-man committee which was formed to guide the work done by the Admiralty on the development of methods of detecting, locating and destroying submarines. The best known and by far the most fruitful product of this association was the familiar "Asdic." Another interesting device was the "leader gear," which provided an electromagnetic system whereby ships could be navigated above and along the route of a cable laid on the sea bed. These and other services rendered by Mr. Hunter during the war earned him the award of the C.B.E. in 1920. During the 1939-45 war he was concerned with the development of special electrical equipment for war purposes and his outstanding achievement was the invention of the fundamental buoyant cable for the destruction of magnetic mines.

In 1919 he was appointed joint manager and chief engineer of Callender's Cable and Construction Company, Ltd., and in 1937 he became a director of the company. For much of this period he was concerned with research and development work on electrical transmission with particular reference to protective systems and cables. He was responsible for the invention of the split-conductor system and the four-conductor system—two methods of providing automatic protection for cables. His presidential address to the Institution of Electrical Engineers in 1933 contained an authoritative appreciation of the cable maker's art and of the prospects for its future development. At that time the solid impregnated paper had for practical purposes reached the peak of its development and, for cables to operate at higher service voltages, other methods of insulation were being sought. With oil filled cables higher working stresses had proved to be feasible but without any corresponding cheapening of the cost of the cable as laid. In the search for further lines of advance increasing attention was being given to methods of placing the dielectric under compression. Indeed, as Mr. Hunter suggested in his address, the development of power cables was about to enter a new phase in which inert gases under pressure were to be used to apply pressure to the paper dielectric and thus to increase its electric strength. In one variant of this idea the gas was to be used as both the impregnating and the pressure medium. There followed a period of intensive work in which these variations were developed and embodied in new high-voltage cables which were installed in various parts of the world. The latest example, a group of five single-core 138kV gas-pressure submarine power cables, providing a three-phase link (with two spare cores) between Vancouver Island and the mainland of British Columbia, was completed and commissioned a month ago as recorded in our pages last week,

Philip Vassar Hunter

Mr. Hunter will be remembered not only for his own direct contributions to cable design but for the unique collection of historical power cables (the Hunter-Hazell collection) which he built up with the help of Mr. J. T. Hazell, who was for many years his personal assistant. This collection which is now in the Science Museum at South Kensington, originated at the time when Mr. Hunter was gathering material for his I.E.E. presidential address in 1933; it soon became clear that many examples of old cables of historic interest would be lost to posterity unless the effort was made to acquire, preserve and catalogue them. So began the task of building the collection of interesting cables and later of writing a book, *The Development of Power Cables*, in which the results of this patient research work can be seen in perspective.

Mr. Hunter's interest in research was well exemplified in the Callender's research laboratory which he was responsible for establishing at Wood Lane in 1934. After the merger which resulted in the formation of British Insulated Callender's Cables, Ltd., he became engineer-in-chief of the new company in 1946, and deputy chairman from 1948 to 1952. He served on the boards of many of the companies in the B.I.C.C. group and was chairman of nine of them, including The British Insulated Callender's Construction Company, Ltd., and British Telecommunications Research, Ltd.

Mr. Hunter's association with the Institution of Electrical Engineers began in 1910 when he became an associate of the Institution. Four years later he became a member and was elected chairman of the North-Eastern centre, an office which he also filled in 1915. After serving on the council of the Institution for many years he was elected president for the 1933-34 session. He has represented the Institution on many committees and has been the chairman of the National Register of Electrical Installation Engineers since 1925 and chairman of the I.E.E. Wiring Regulations Committee since 1934. From 1939 to 1941 he was president of the Electrical Industries Benevolent Association. For his services to the Institution and to the electrical industry as a whole he was made an honorary member of the Institution in 1951. Since 1933 he had been a fellow of the American Institute of Electrical Engineers. He was president of the British Electrical Power Convention in 1952. In May, 1956, he was elected the first chairman of the newly formed National Inspection Council for Electrical Installation Contracting. He also served on many committees of the British Standards Institution and the Electrical Research Association.

A memorial service will be held at St. Margaret's, Westminster, on Thursday, November 8th, at 2.15 p.m. The service will be conducted by the Rev. Dr. E. G. Jay and the address will be given by the Rev. C. L. Creswell, C.V.O., chaplain to the Council of the Institution of Electrical Engineers.

Time Study and Statistics

By A. W. SWAN, B.A.Sc., A.M.I.Mech.E.

No. I

TIME-STUDY by stop-watch was invented in the early part of this century as a part of what was called scientific management and used principally as a basis for the piecework and bonus payment systems of Taylor, Gantt and others. Whether by stop-watch, special film techniques or other mechanisms, time-study has remained and still is primarily a function linked with payment for work done. Motion and method study, invented by Gilbreth, have remained, until fairly recently, separate from time-study.

Present-day industrial statistics may be defined as the statistics of the small sample. As it is seldom possible to have available for analysis the total possible amount of numerical information on costs, weights, times, &c., it is usually necessary to examine only a sample of this numerical information. Statistical methods provide ways of assessing from such samples the properties of the "populations" from which they are drawn within defined limits of probability. A basic assumption in industrial statistics is that no series of measurements remain exactly at a given value but vary about that value. The variation may be narrow or wide, symmetrical, "skew" or rectangular, but it always exists.

Industrial statistics as defined above is a relatively new arrival, and it has only been during and since the war that there has been any real impact of this kind of thinking on industry. The pioneers of time-study were aware that time-studies were samples of information and that there was variability in the time-study man, the operation studied and the operator. They made suggestions to deal with variability, however, not as the present-day statisticians would by examining a complete situation, but by selection of "reasonable" or "representative" operators, jobs and machines to study.

The term "statistics" seems to conjure up to many industrialists techniques that are hard to understand and complicated to use, yet the statistical point of view is essentially a simple one. It may be summarised as: (1) measurements are always variable so that a single measurement does not represent the whole situation; (2) since there is variability one must assess not only a mean value but the extent of the variability; (3) more than one measurement is necessary to make such an assessment; (4) one can estimate total effects with reasonable accuracy from what may be considered to be a small sample of such measurements.

The statistical device of plotting numerical information in the form of distributions is extremely simple and can be used without any training in statistical theory. In connection with time-study it provides a very valuable method of analysis.

Examples of Statistical Methods Applied to Time-Study

The following section gives some examples of the application of statistical thinking to time-studies, using principally the plotting of results as distributions and occasionally the use of more advanced techniques, particularly correlation.

(*a*) *Time-Studies Without Rating.*—The following examples are concerned with time-studies made in connection with heavy machines, such as steel rolling mills, cranes, &c., where "rating" has not been used.

Case 1.—It was desired to condense, if possible, over sixty-five groups of "expected tons per hour" for a certain steel cogging mill (rolls ingots into blooms) so that clerical work could be simplified. By plotting actual results taken from works records over six months in the form of distribution curves as shown in Fig. 1, it became possible to use

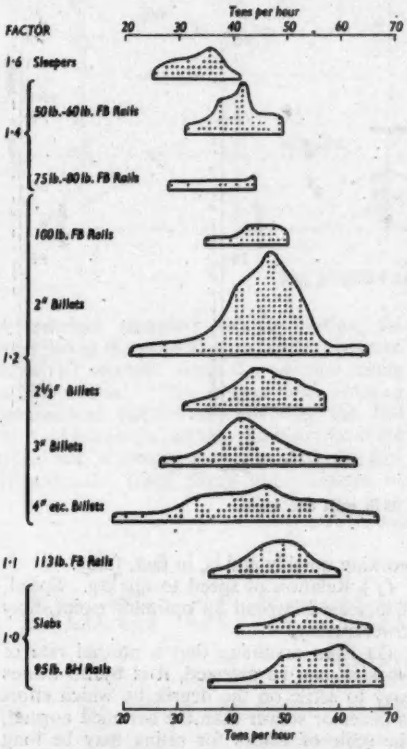


Fig. 1—Net rolling rates, tons per hour

six groups instead of the sixty-five normally used. It was found, for instance, as will be seen in the diagram, that there was no material difference between the average rolling rates for the different sizes of billets and that a single grouping would suffice.

The visual indications of the distribution curves were checked statistically before the groupings were adopted.

The above case does not illustrate the application of statistical methods directly to time-study, but to recorded actual performances in which every time-study man and cost accountant is interested, the method used being a quick and simple yet accurate way of arriving at the time element in standard costs.

Case 2.—In order to gauge mill capacity, time-studies were made in the roughing and finishing mills in a steel works which produced rails. Since the runout bed on which the rails are finally cooled would only take rails up to a certain length, it was necessary in the case of a certain lightweight rail to roll the ingot into a bloom, saw the bloom in two immediately after rolling and proceed to roll each half of the bloom successively into a rail short enough to be accommodated on the cooling bed. It was found in connection with this particular rolling that the manipulation time prior to the first pass of the first "half" rail showed a very long rectangular distribution, whereas the corresponding manipulation time for the second "half" rail showed a distribution with a slight tail, as shown in Fig. 2. As there was no apparent reason why there should be such a difference between the first and second "half" rails, investigation was made of a number of rollings in chronological order. It was found that the ingots were being rolled at irregular intervals, but that once an ingot was rolled into a bloom it was then promptly sawn and the resulting two halves rolled. Thus the interval between the arrival of the first half was irregular and showed as a rectangular distribution, while the interval between halves was regular.

It was deduced that a rectangular distribution of times for industrial processes may be an indication of trouble at the process immediately prior to that being studied, a deduction borne out in subsequent analyses.

Case 3.—A study of a bottleneck in a rail bank (outgoing store) in which rails are accepted and despatched, included time-studies on two sets of cranes which in sequence handled the rails from their arrival from the rail-straightening department to their departure on British Railway wagons. The first crane deals with rails as they arrive in sequence on a conveyor, one at a time, from the rail-straightening department. When there is a "lift" of five rails, the crane picks them up, carries them along a gantry and drops some half-way and the remainder at the end of the run. The crane then returns along the gantry and picks up another "lift." In theory, five rails should arrive during the delivery run of the crane, so that when it returns a new "lift" is ready. There may, however, be a waiting period. Thus the operation of the crane may be divided into: (1) lift, (2) travel, (3) unload, (4) return travel, (5) wait.

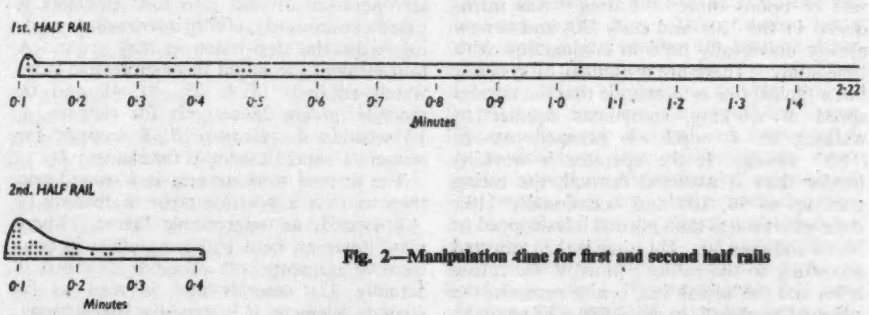


Fig. 2—Manipulation time for first and second half rails

The distributions are illustrated in Fig. 3, and the deductions are:

(1) *Lift and Unload.*—Here we find symmetrical narrow distributions indicating uniform practice and good work.

(2) *Travel and Return.*—In this case the distribution is two humped (bi-modal) and

symmetrical, with a reasonably narrow base as before. This indicates good uniform work, the two modes being the result of the fact that some of the rails are dropped halfway along the gantry and the remainder at the end of the gantry.

(3) *Wait.*—This is another rectangular distribution, and the deduction is the same as that in case 1, indicating chaotic conditions at the previous operation, in this case rail straightening.

The study of the two cranes working on a single gantry at the despatch stage at the same rail bank was interesting in other ways.

It had been thought that the purchase of a new crane might be necessary, but the distributions from the time-studies, coupled

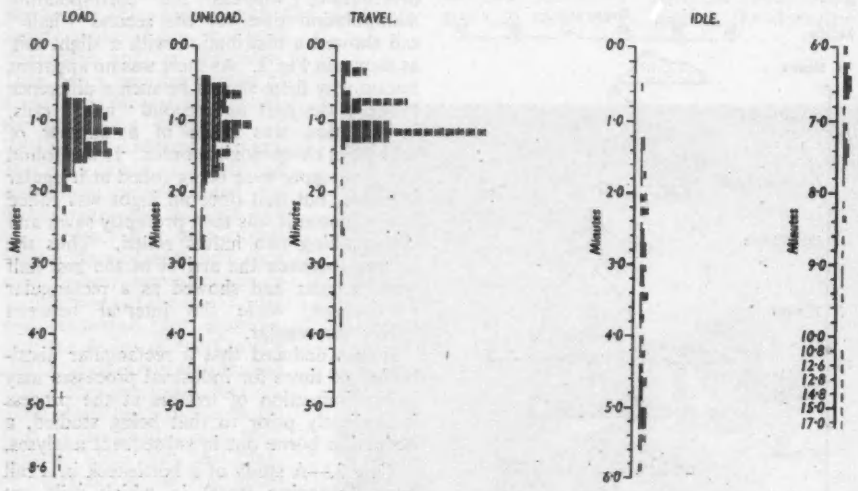


Fig. 3—Railbank crane, 95 lb rails one week

with chronological analysis of the same data, showed that by making various improvements in planning the order of events, the efficiency of the crane usage would improve to such an extent that this would not be necessary. Examination of the time-study information in distribution and chronological form also showed clearly the interesting fact that the team of two cranemen had worked out an efficient way of operating so that they did not get in each other's way and formed an excellent team.

(*b*) *Time-Studies with Rating.*—Early time-study was a straightforward timing of machine or manual operations, broken into convenient elements. From such studies a representative time was assessed for the operation and used as a basis for the piece rate or bonus time. "Rating" was introduced in the '20s and early '30s and is now almost universally used in conjunction with time-study. There are a number of systems, but a typical one is to assume that the normal speed of working, sometimes equated to walking at 4 m.p.h. is assessed at an "80" rating. If the operator is working harder than is assumed normal, the rating goes up to 90, 100 and occasionally 110; if the effort is less than normal it is dropped to 70, 60 and even 50. This time is then adjusted according to the rating; thus, if the rating is 90, and the actual time is nine seconds, the adjusted time will be $9 \times 90/80 = 10$ seconds.

The justification put forward for rating time-studies is that to take "actual" times only as a basis for setting rates of payment would be an open invitation to the operator to work at less than his or her normal speed. Whether or not this opinion is valid, the difficulties in rating are many and among these difficulties the following can be indicated (a normal working rate of 80 being assumed for convenience):—

(1) The rating "80" is usually taken to be equal to the effort in walking at the rate of 4 m.p.h.; but it is one thing to equate rating to the speed of walking and another to equate rating to the great variety of manual and manual-machine operations, bearing in mind the variability of:

(*a*) Job conditions (machines, &c.).

(*b*) Training.

(*c*) Psychological conditions in the operator.

(*d*) Fatigue.

(*e*) Relation of actual speed to appearance of speed; an apparently slow operator may be working faster than one who seems to be working quickly and is, in fact, fussy.

(*f*) Relation of speed to quality. Speed, if increased beyond an optimum point, may lower quality.

(2) Even assuming that a normal rate of working can be assessed, it is by no means easy to settle on the degree by which effort is faster or slower than the assumed normal, the scale of values for rating may be long or short, e.g. from 50 to 110, or from 60 to 100. The scale of values may be symmetrical or non-symmetrical about the standard (80), e.g. 60, 80, 100 or 50, 80, 100. The steps of the rating may be in 5's or 10's, e.g. 70, 75, 80 &c., or 70, 80, 90, &c.

(3) Time-study is taken by stop-watch to the nearest second or 1/100th minute, and nowadays usually on a continuous basis. Thus, an operation divided into four elements is timed continuously, taking intermediate readings from the stop-watch as they occur. A four-element job might have successive stop-watch readings of 1, 23, 40, 48 and 60 seconds, giving 23 seconds for element *A*, 17 seconds for element *B*, 8 seconds for element *C*, and 12 seconds for element *D*.

The normal working unit is 1 second and there is thus a possible error in reading of $\pm\frac{1}{2}$ second, an appreciable factor. There may, however, be a balancing effect in consecutive elements. If element *A* above is actually $23\frac{1}{2}$ seconds and is read as 23 seconds, element *B* is actually $16\frac{1}{2}$ seconds, but is read as 17 seconds.

(4) If the element time is short, unless the rating is considerably higher or lower than the standard, the adjusted time will be very little different from the observed time. Thus, if the observed time is 5 seconds and the rating is 85, the adjusted time is $5 \times 85/80 = 5{\cdot}3125$ seconds, which, rounded off to the nearest second, is still 5 seconds. The same effect is to be found to a lesser degree up to 8 seconds, for which the rating must be below 75 or above 85 to make a change of a full second from "observed" to "rated" time.

(5) Rating is associated with a rounding-off error apart from the actual observed length of time. If the actual time of 5 seconds is rated at, say, 60, the rated time will be $5 \times 60/80 = 3{\cdot}75$ seconds, which will be rounded off to the nearest second at 4 seconds. The "rating" rounding-off error is thus $4 - 3{\cdot}75$ seconds $= 0{\cdot}25$ second, or 6 per cent. On a longer study this might well be serious, especially when it is realised that a rate of payment depends upon the results.

Adjustments are made for these rounding-off errors in Courtauld's Work Study practice.

(6) The "easy number" effect may occur; that is, a subconscious stressing of the round numbers in ratings, 60, 70, 80, 90, &c., coupled with a corresponding neglect of the in-between numbers, 65, 75, 85, &c.

The above conditions are realised by all time-study practitioners, but the application of statistical thinking to their solution is still somewhat rare. Among the published works attention is particularly directed to a small publication by Martin Wiberg under the title *Work-Time Distribution*, which cuts right to the heart of the matter.

Wiberg stresses that work-studies are always samples; they should be "representative" rather than "purposive"; the actual shape of the distributions are very revealing in regard to degree of difficulty, stage of training, &c., and should therefore be used whenever possible.

Possible Deductions from Statistical Analysis

Before analysing some actual rated time-studies let us consider some of the deductions which may be made from the correlation-regression scatter diagrams for observed times and rated times (actual × rating/80).

The relationship between actual (observed) time, and the applied rating is somewhat unusual among industrial linkages in that, either may be considered the dependent variable. As the time-study man may be considered to be primarily interested in the time corresponding to rating, time has been taken in this instance as the dependent variable and the reciprocal of the rating as the independent variable. In D. J. Desmond's papers the reciprocal of the rating, which he calls the reciprate, is the dependent variable.

Under ideal conditions one would expect that there would be a straight line relationship between observed times and the

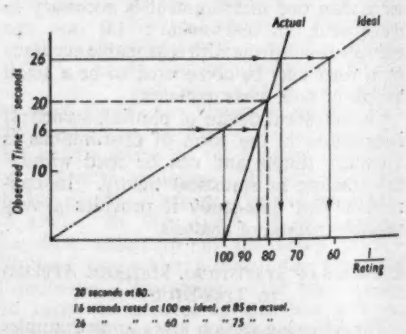


Fig. 4—Relation of ideal to actual rating

reciprocal of the rating, the line being that from the origin "0" passing through the time for the "80" (normal) performance. This may be called the "ideal" line. The "actual" line tends to be steeper than the "ideal." As will be seen from Fig. 4, when

the "actual" line is steeper than the "ideal" the time-study man is using a compressed range of rating values, underrating the faster times, e.g. 85, where the "ideal" suggests 100, and overrating the slower times, e.g. 75, where the "ideal" suggests 60. The steeper the "actual" line in relation to the "ideal," the greater is this effect and the smaller will be the alterations by rating of the actual times until in the extreme case, with a vertical "actual" line there is only one rating in use. This will mean that the distribution of rated times is precisely the same in shape as the distribution of observed times, at the same level if the rating is 80, moved upwards bodily if the rating is more than 80, and moved downwards bodily if the rating is less than 80.

The correlation scatter diagram yields further information through the value of r^2, the square of the correlation coefficient, and s, the standard deviation of the scatter about the regression line, which is the best fit to the cloud of points; r^2 and s are measures in the opposite direction (r^2 increases while s decreases), of consistency in rating. If r is so small as not to be significant in the statistical sense, no definite regression line can be fitted to the points and there is therefore no traceable linkage between rating and observed times. With r significant but small, s is large, indicating a considerable variation in the rating. Thus, in a single study under such conditions one might find a rating of 60 applied to times between 20 and 40 seconds and a rating of 70 applied to times between 15 and 35 seconds, giving an overlap.

The variability in rating can be divided into components, that attributable to the personal variation of the time-study man, and that attributable to the variability in the difficulty of the job. If the mean time assessed at a rating of 80 under what are considered to be standard conditions is 10 seconds and the time-study man's personal error is assumed to be ±1 second an 80 rating may be allotted to 10+1=11 or 10−1=9 seconds. If, however, we find an 80 rating given to a time of 15 seconds it is reasonable to assume that there is a "variability" or "difficulty" margin of between 4 and 6 seconds (15−11=4, or 15−9=6 seconds). The greater is the "job variability" or "difficulty" component in the total variability the smaller will be the link between rating and observed times, until in the extreme condition rating will have no effect whatever in adjusting observed times. When this occurs the distribution of rated times will be almost exactly the same as the original distribution for observed times, with in this case no change of mean as may be possible with the "steepness" effect.

It follows from the above reasoning that if we compare time-studies of different operators on the same job by the same time-study man, variations in the "difficulty" variability will indicate differences in the difficulty experienced by the different operators in handling the job.

Fig. 5 shows an imaginary time-study considerably over-simplified to illustrate the effects on the ratings, and through the ratings on the adjusted times, of "steepness" of the "actual" regression line in comparison with the "ideal" line. The observed times are the same for all four cases, giving skew distributions with a mean of 10 seconds.

In *A* the operator is considered to be working at about 80, in *B* at about 70. In *A*1 and *B*1 the ideal and the actual lines coincide, while in *A*2 and *B*2 the actual line is steeper than the ideal. It will be observed from the figure that for *A*1, in which the ideal and actual lines coincide, the rated times form a

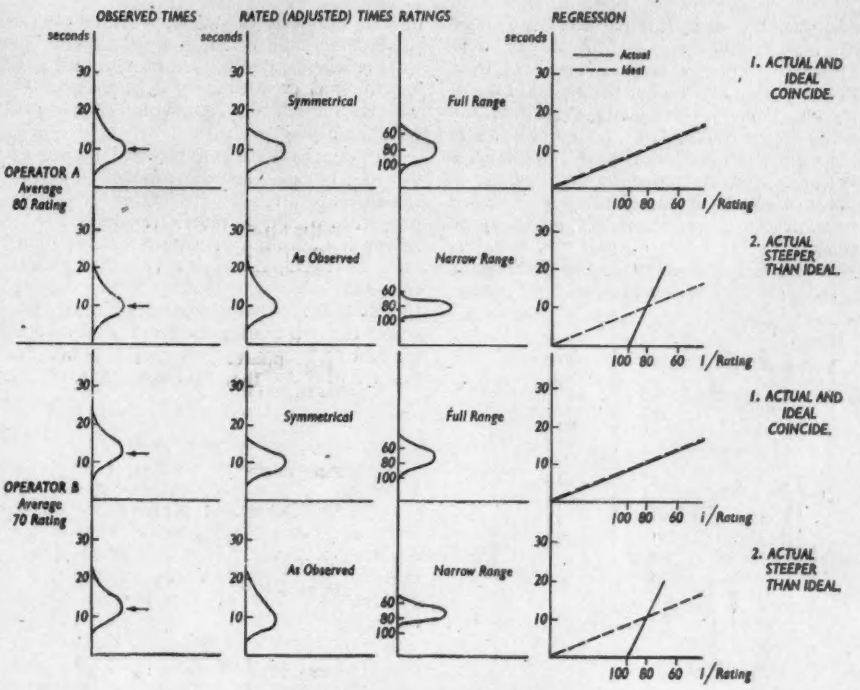


Fig. 5—Effect of steepness of rating

symmetrical narrow-based distribution, the mean being the same as that for the observed times, 10 seconds, since the average rating is 80=normal. The ratings also form a symmetrical distribution covering the full range of available ratings. In *A*2, where the actual line is steeper than the ideal, the distribution for rated times approximates in shape to that for the observed time, with the mean still at 10 seconds as in *A*1. The distribution for ratings shows the effect of compression of the range of values used.

In *B*1 and *B*2 the effects are similar, except that the mean of the rated times is reduced from 10=mean of the observed time to 10×70/80=9 seconds (to the nearest second).

(To be continued)

North of Scotland Hydro-Electric Schemes

No. VIII: THE GARRY AND MORISTON SCHEMES—PART V*

(Continued from page 579, October 26th)

The adjoining catchments of the Garry and Moriston rivers in Inverness-shire have for many years been recognised as favourable sources for the development of hydro-electric power. The North of Scotland Hydro-Electric Board's developments here will yield about 383 million kWh annually, from an installed capacity of 106MW. Civil engineering aspects of the upper stage of the Moriston scheme are discussed hereunder.

THE civil engineering works of the Moriston scheme, like those in Glen Garry, present no little variety and interest. The two main reservoirs (details were given in Fig. 1 and Table II *ante*) are each formed by a concrete gravity dam. The design of these dams has followed well-established practice, but their construction is noteworthy for the use of the Trief process for concrete making and for the precast concrete blocks used to face the dams, which eliminate shuttering. The economies effected by these methods have restored the gravity dam, on this scheme, as an economic competitor with buttress and rockfill dams.

The trend away from the gravity dam, and the use instead of buttress designs of various kinds, was discussed at some length in our article on the Tummel-Garry scheme. Here we have a different approach, aimed at giving comparable savings without altering the form of the dam. This situation leads to the speculation whether the buttress dams could not themselves make use of Trief concrete, thus effecting a double saving. In this case, however, the use of the facing blocks influenced decisively in favour of a simple structure, thus reinforcing the view, held universally in American civil engineering for instance, that construction is made easier by the simpler gravity shape, and the extra concrete it requires is of comparatively small importance once the plant to make it is in operation. It remains to be seen whether, with the comparatively cheap concrete of the Trief process, the simple gravity shape will prove the best in most cases, or whether refinements such as buttress dams and prestressed dams will still give advantages in cost. In the case of the Moriston scheme, the maximum height of Cluanie and Loyne dams are, respectively, 131ft and 68ft.

The substitution of some of the cement in

* No. I: "An Introductory Survey," appeared July 14, 1950; No. II: "The Loch Sloy Project," July 21-August 4, 1950; No. III: "The Fannich Project," June 8-15, 1951; No. IV: "The Mullardoch-Fasnakyle-Affric Project," April 11-25, 1952; No. V: "Some Schemes for Local Supply," October 16-23, 1953; No. VI: "The Tummel Garry Scheme," September 2-23, 1955; No. VII: "The Shira Scheme," April 20-27, 1956.

concrete by a hydraulic substance such as blast-furnace slag, is of course, well-known. "Fly-ash," a waste product from power station boilers, has been used in building the Hungry Horse dam in U.S.A. and many recent Italian dams, including some of the slender arched ones, have pozzolana, a volcanic product, added to the concrete in place of some cement. The Trief process is to some extent analogous to "metallurgical cement." The latter, however, is made by grinding dry granulated slag with Portland cement clinker, whereas in the Trief process

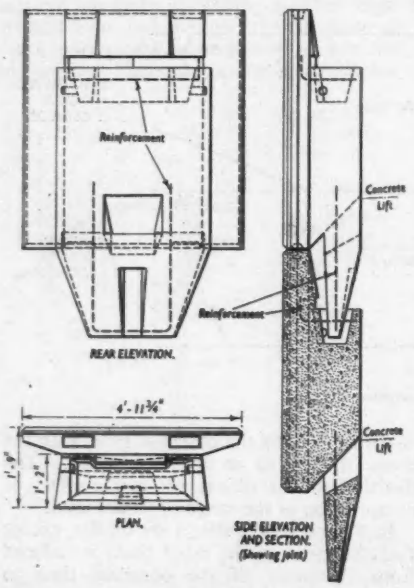


Fig. 11—Precast concrete facing blocks for upstream faces of dams on the Moriston scheme. The downstream blocks are similar in principle but are inclined, and so supported by a prop

wet-ground slag (which is finer than the dry-ground product) is added directly to the concrete mix.

There are several processes whereby blast-furnace slag may be made into a suitable additive. A report on the subject was published,† following an investigation by the Building Research Station during the war, caused by a threatened cement shortage at that time. But, in spite of evident economies, the method has not been taken up by British civil engineers to any great extent, the work in Glen Moriston being the first major example of which we are aware. However, the Central Electricity Authority has recently tried to encourage the use of power station ash, in rather the same way as was done at Hungry Horse dam, and three dams now under construction on the Hydro-Electric Board's Breadalbane scheme make use of it. With that material, however, we understand that only 30 per cent of the cement can be replaced. With the Trief process, 70 per cent of the cement is replaced; this proportion allowed a saving of about 20,000 tons of cement (in 298,000 cubic yards of concrete) on the Loyne and Cluanie dams. The process was used to construct the Bort dam in the French Massif Central (THE ENGINEER, September 16, 1949) and its undoubted success on that project led to an awakening of interest in Great Britain, and its eventual adoption at Glen Moriston.

In the Trief process only slags of a definite composition, within fairly close limits, are used. They are granulated at the blast-furnace and subsequently ground very finely in the presence of water. The resultant product may be dried, but in the case of works where a considerable quantity is required, as at Moriston, it is cheaper to use slag in the form of slurry, thus dispensing with the drying process.

The composition and physical nature of the slag is such that the product is a true cement with very considerable hydraulic properties which, however, are largely latent. In use the addition of a base such as soda, lime or Portland cement (which contains free lime) is necessary to activate the material, the latter being specially suitable in the case where the slag is used as slurry, as a certain amount of control is thus obtained over the water/cement ratio in the concrete mix.

Concrete Plant at Cluanie Dam

The first stage of slag treatment for the Trief process must be carried out at the ironworks. The slag is granulated by quenching by jets of water. The granulated slag is inert, and can be stored in the open at the constructional site. It is then ground wet, in a ball mill, and the slurry is added to the concrete as part of the normal weigh-batching.

The slag plant at Cluanie dam consists of two combination tube mills, each 28ft long and 5ft in diameter, each able to pulverise 3½ tons of slag in an hour, from a feed size of about ¼in down to 99 per cent passing a B.S.S. 170 mesh.

The resulting slurry is stored in two tanks, each of 80 tons (dry) capacity, which are continuously agitated. There is then a steel pipe, extending 200ft, along which the slurry may be pumped to a hopper at the concrete station, and the slurry is mixed with the other constituents in the normal weigh-batching procedure. The water content of the slurry is known and so the correct quantity of water can readily be added to the mixture. The slurry pipes are cleaned, after use, by blowing a rubber ball through them.

Granite rock of good quality is found at Cluanie dam. A quarry for aggregates has been opened close to the dam, equipped with primary and secondary crushers, washing and screening plant, and storage hoppers for the following grades of aggregate: 4–2½in, 2½–1½in, 1½–¾in, ¾–⅜in, ⅜–$\frac{3}{16}$in; and sand less than $\frac{3}{16}$in. Belt conveyors lead from the storage hoppers to the concrete station, which has weigh-batching plant and two 2 cubic yard mixers and one 1 cubic yard mixer. The maximum capacity of the plant is 90 cubic yards per hour. Concrete for the dam is discharged into cableway skips, which are transferred on rails to a position under the two 10-ton cableways which span the dam site.

This plant also includes belt conveyors to take the concrete to the adjoining precasting shed, where the facing blocks are made; and a belt conveyor to a second concrete hopper. Here it can be loaded into 4 cubic yard mixer trucks, which are used to transport concrete to the Loyne dam.

Concrete made in this manner has a lower early strength than normal Portland cement concrete of equivalent standard, but at ninety days, it has been found, the two are comparable in strength. No markedly differing properties have been observed for the Trief concrete in the site testing. However, it is claimed for the process that it produces a dense impermeable concrete which has less shrinkage than ordinary concrete and good resistance against frost and aggressive waters.

Facing Blocks

The sketch, Fig. 11, clearly illustrates the use of the facing blocks on the upstream face of the dam. The "tail" of each block fits into a corresponding recess in the lower block. After plumbing the block, which at this stage is free to rotate on the "joggles" shown in the sketch, the "tail" is grouted into position and the joints up to the mid-point of the block are pointed. The next "lift" of concrete up to about the centre of the upper block can then be placed. There are special blocks for the inclined downstream face, stop-ends, and the spillweir crests. The top level of each lift is fixed by the downstream blocks, which have to be propped. The blocks are made of ordinary Portland cement concrete. Thus they replace part of the richer "facing" mix usually used for gravity dams, although the richer mix is still in fact used behind them, for a thickness of about 4ft. The blocks are left in stacks across the top of the dam, by the cableways, and are then handled into position by a light crane. As a result, Cluanie dam has not been

Fig. 12—Cluanie dam is here shown at an advanced stage of construction, with work in progress on the piers of the spillweir. The quarry which supplied aggregates for the two dams is to the right

† "Investigations on Granulated Blast-Furnace Slags for the Manufacture of Portland Blast-Furnace Cement." National Building Studies Technical Paper No. 3. H.M. Stationery Office.

built up in a number of separate "columns," each at a different stage of construction, as is generally done with a gravity dam. The lifts are placed more or less uniformly right along the top of the dam, to give the minimum of interruption to the use of the cranes. The appearance of the blocks on the nearly completed structure of Cluanie dam is shown in Fig. 12, which is a reproduction of a progress photograph taken last July.

At Loyne dam the position is rather different, since the only plant consists of three Scotch derricks. All concrete and facing blocks are brought from the plant at Cluanie dam, and need only to be placed in position at the second site.

The total number of blocks needed for both dams is about 34,450, i.e. about 34,450 cubic yards of precast work. The precasting shed at Cluanie dam has been laid out in the manner of a permanent factory for precast work, with a light overhead crane, vibrating tables, and so on. Apparently the use of these blocks has not given a significant direct saving in cost. Their chief advantage is that they give an almost complete independence from carpenters. This class of labour has always been in short supply on the Scottish schemes, and jobs have been held up from that cause.

Hydraulic Design at Loyne and Cluanie

An overflow weir, on the downstream side of Loyne dam, encloses the headpond and the inlet shaft of the tunnel to the Cluanie reservoir. The crest level of the weir is 703·5, that is 1·5ft higher than the spill level of Cluanie reservoir. Loyne reservoir spill level is 745. Under normal conditions the water diverted from Loyne to Cluanie will be passed through a 550kW turbo-generator set situated in the foundations of the dam, the draught tube discharging directly into the inlet shaft at 674·0 O.D. Operation of the upper scheme demands that Cluanie reservoir should be kept up at the expense of Loyne.

Loyne dam contains two 5ft diameter culverts ; a scour culvert, fitted with a discharge regulator which discharges into the tunnel headpond, and a dewatering culvert fitted with a jet disperser which discharges into the river. The turbine intake is formed by a separate square section culvert, the upstream end of which is protected by screens. In addition, a retaining wall has been formed on the bed of the reservoir to arrest silt. There is a control gate in the turbine inlet operated by a winch. No compensation water is called for at this dam. There is, however, the usual spillweir at the crest, but because of the comparatively low height of the dam the usual curved spillway bucket has been omitted.

The tunnel from Loyne to Cluanie (statistics of the tunnels of the scheme are given in Table IV) has been lined only where bad rock occurred and at special points. Experimental lengths of invert lining were done in a macadam with a bituminous binder. There is a gate in a shaft and stoplog slots at the Cluanie end of the tunnel, with a culvert discharging downstream from Cluanie dam, for emptying the tunnel.

Cluanie dam has the usual scour and dewatering culverts with a compensation water turbo-alternator supplied from a branch of the former culvert, which terminates in a needle valve. The dam has a 450ft long spillweir. The culvert controls on the upstream face of both Loyne and Cluanie dams include the provision of guide grooves with which a stoplog gate can be lowered over the mouth of any culvert ; at the downstream ends of the culverts are sluice valves. A road bridge formed of prestressed units gives access across the spillweir of Cluanie dam to the tunnel.

Ceannacroc Tunnels and Power Station

The intake of the tunnel to Ceannacroc power station is on the left bank of Cluanie reservoir, close to the dam. It consists of a cutting in the rock, somewhat similar to that in the Quoich reservoir, with an enlargement in the tunnel, and a shaft above, housing a guard gate, the control gate being at the surge shaft. The gentle slope of the reservoir bank favoured this layout in preference to the more usual tower-like structure housing screens and gates, which is characteristic of other schemes.

Table IV—*Tunnels of the Moriston Scheme*

	Length	Equivalent diameter	Slope	Construction
Loyne tunnel	7,600ft	12ft 0in	1 in 800	Unlined, horseshoe cross section, 113 square feet, connecting Loyne and Cluanie reservoirs
Ceannacroc tunnel :				
Low pressure tunnel	14,000ft	12ft 0in	1 in 378	Horseshoe cross section, concrete lined
High pressure tunnels (two)	100ft 111ft	10ft 0in 5ft 0in	1 in 21·1 1 in 231	Two steel-lined intake tunnels to machines in Ceannacroc power station
Tail-race tunnel	1,706ft	19ft 4½in	1 in 853	—
Side-stream intake to low-pressure tunnel	339ft	5ft 10½in	1 in 2·5	Intake from additional catchment 1·4 square miles
Doe branch tunnel to low-pressure tunnel	5,781ft	9ft 6in	1 in 40·36	Horseshoe cross section, lined tunnel. Additional catchment 13·6 square miles
High pressure shaft	170ft 6in	12ft 6in	Vertical	—
Surge shaft	180ft	45ft	Vertical	—
Glen Moriston tunnel	22,000ft	20ft 9in	1 in 50 and 1 in 5,250	Horseshoe cross section, unlined tunnel, forming tail-race from lower power station
High pressure shaft	300ft	15ft	Vertical	Circular section, concrete-lined

Note.—Details of access tunnels and other tunnelling for the underground power stations are not given in this table.

Details of the tunnel are listed in Table IV. Two adits were used to build it, thus giving four working faces. The lining was largely concreted from plant installed at the adit. Here a slurry tank was added to the normal concreting plant, so that Trief concrete could again be used. The tunnel lining contains about 14,500 cubic yards of Trief concrete and a further 790 tons of cement was saved. The concrete of the power station and pressure tunnel was, however, constructed with ordinary Portland cement concrete.

Ceannacroc power station was a straightforward work to construct, its principal novelty lying in the fact that it will be the first major underground power station in this country. The low-pressure tunnel from Cluanie reservoir ends at an unthrottled surge shaft, shown in Fig. 13, from the base of which a vertical shaft descends to the power station level. At the bottom of this vertical shaft there is a right-angled bend, and two steel-lined, high-pressure tunnels lead off, one to each machine. The high-pressure section is short, the distance between

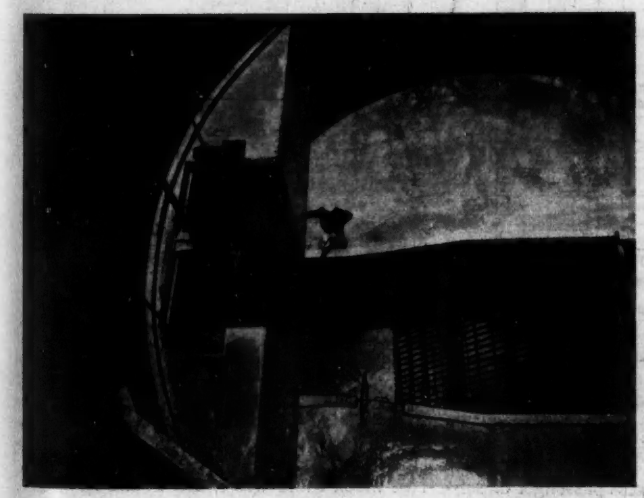


Fig. 13—Bottom of the surge shaft serving Ceannacroc power station. Flow from the main tunnel is controlled by the gate shown on the left. The vertical shaft descending to the power station is below the screens

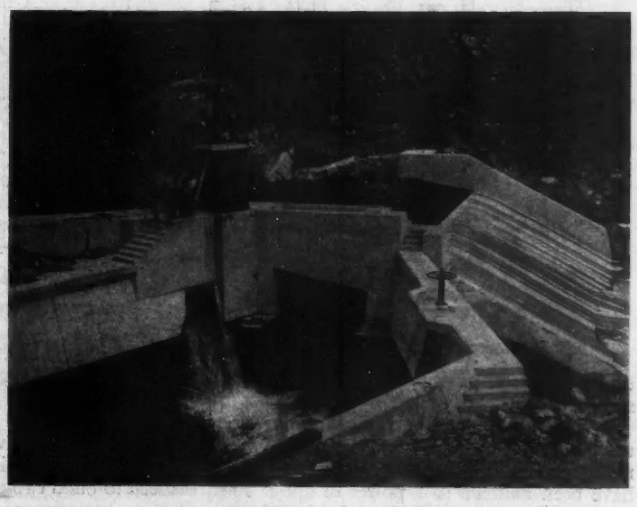


Fig. 14—Intake weir on the River Doe. Water flows into the aqueduct through the screens in the weir crest. In times of flood, the flow passes over the weir and thus sweeps debris clear of the screens

the centre lines of the vertical shaft and the turbines being 152ft.

The power station chamber has a barrel vault of concrete over it, but the walls consist of the natural rock surface, panelled in appearance by the reinforced concrete beams and columns for the overhead crane, which are built almost against it. Some of the Swedish underground stations have been built in this way, which is effective and functional, architecturally. The tail-race is a free flow tunnel, and no special works were needed to cater for surge on the downstream side. The access tunnel slopes down to the station at a gradient of 1 in 9, and with a road width of 10ft.-6in. A ventilation tunnel gives access to the tail-race tunnels, but all other facilities—such as a dewatering pit and the inlet valves—are accommodated within the confines of the main excavation for the power station chamber.

The various smaller works needed to bring in subsidiary streams are well illustrated by Fig. 14, which show the intake on the River Doe. The screens in the crest of the weir, which are self-cleaning and through which the useful flow is diverted, are clearly shown, with the culvert beneath them leading to the pool shown to the left of the illustration. There are coarse screens and a bulkhead gate at the other end of this pool (not shown in in Fig. 14) at the portal of the Doe tunnel. The water shown cascading from the square culvert is not discharged during normal operation. This culvert is a dewatering culvert for the river channel on the upstream side of the weir, and is controlled by a 4ft by 4ft sluice ; the small structure adjacent to it is a recording house. There are two scour outlets, one leading from a sump in the channel under the weir, and one from the stilling pool.

All the upper works of the Moriston scheme, including the dams, tunnels and civil engineering works at Ceannacroc power station, were built by one firm of contractors —the Mitchell Construction Company, under the direction of Sir William Halcrow and Partners. The slurry mills for the Trief concrete were supplied by Edgar Allen and Co., Ltd., and the blast-furnace slag came from Colvilles Ltd's steel works in Lanarkshire.

(To be continued)

Motive Power on Sea and Land

By T. A. CROWE, M.Sc.

No. II—(*Concluded from page 581, October 26th*)

Abstracts are printed here of the presidential address delivered by Mr. T. A. Crowe before the Institution of Mechanical Engineers on Friday, October 19th. Mr. Crowe drew upon his own experiences in marine and railway engineering. We print here those parts of the address which related to the Royal Navy and the development of diesel locomotives.

Types of Diesel Locomotive

THE diesel locomotives available to railways and industrial users to-day can be divided roughly into three categories according to the transmission used to couple the diesel engine to the road wheels. These three types are :

(1) Diesel-mechanical.
(2) Diesel-electric.
(3) Diesel-hydraulic.

(1) *Diesel-Mechanical Locomotives.*—The mechanical drive has the advantage of cheapness, but it has the disadvantage that there is obviously a limit to the number of gears which can be fitted and, therefore, during acceleration the drive proceeds in a series of steps.

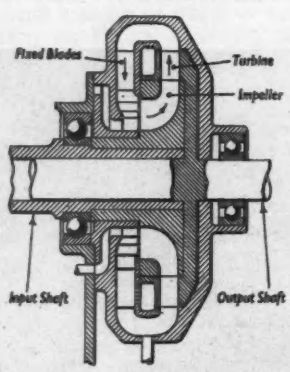


Fig. 5—Arrangement of torque converter

Diesel-mechanical shunting locomotives are usually confined to the smaller sizes, say, up to about 200 to 300 b.h.p., although a few have been built up to a power of about 500 b.h.p. The largest diesel-mechanical locomotive which has so far been built is the Fell locomotive of 2000 b.h.p., which is operating on British Railways. In this locomotive four 500 b.h.p. diesel engines are coupled to a common gearbox from which the drive is taken by quill shafts to the two inner driving axles.

(2) *Diesel-Electric Locomotives.*—The electric drive has the advantage of an infinitely variable gear between the diesel engine and the driving wheels, and, up to the present, the majority of main line diesel locomotives in use throughout the world are fitted with this form of transmission.

One of the first successful diesel locomotives to run on British Railways was a 300 to 350 b.h.p. diesel-electric shunting locomotive manufactured in 1934 by the English Electric Company and my old firm of Hawthorn Leslie and Co. at Newcastle upon Tyne.

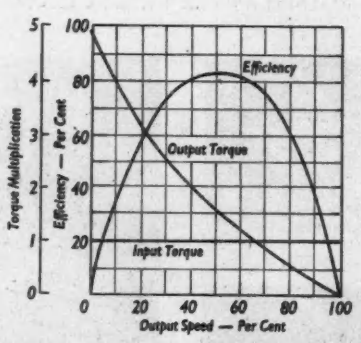


Fig. 6—Performance characteristics of torque converter

After the 1939–45 war the former London, Midland and Scottish Railway Company decided to build two express passenger diesel-electric locomotives in order to obtain experience in the operation of this type of motive power. These locomotives were built at Derby to the design of Mr. Ivatt, chief mechanical engineer of the L.M.S.R., and the diesel engines and electrical equipment were supplied by the English Electric Company.

In 1950 my company built an 827 b.h.p. diesel-electric locomotive for the London Midland Region of British Railways. This locomotive is intended to handle intermediate passenger train services. The diesel engine is of the Paxman four-cycle vee type having sixteen cylinders, 7in bore by 7½in stroke, and runs at 1250 r.p.m. Two exhaust gas turbo-superchargers are fitted and at full power the brake mean effective pressure is 110 lb per square inch. The maximum tractive effort is 34,500 lb, and the locomotive weighs nearly 70 tons in working order.

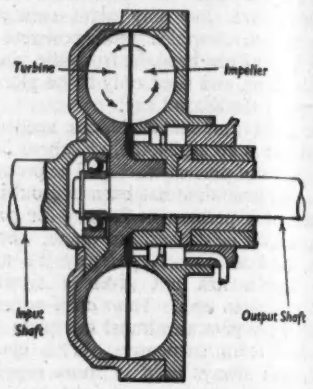


Fig. 7—Arrangement of hydraulic coupling

(3) *Diesel-Hydraulic Locomotives.*—I propose to deal rather more fully with the diesel-hydraulic locomotive than I have with the two previous kinds, because it is the one with which I personally have had most experience. This form of transmission, which has an efficiency comparable with that of the electric drive, has made rapid headway in the last few years because of a growing realisation of its advantages. The Voith/North British hydraulic transmission is based on Dr. Föttinger's original single-stage, hydraulic torque converter, which he patented in Germany in 1905, for coupling a relatively high-speed steam turbine to the low-speed propeller shaft of ships. A number of vessels were built with this system for the German Navy prior to the 1914–18 war. When Sir Charles Parsons developed mechanical gearing for this purpose, to which reference was made earlier in this address, the Föttinger transformer fell out of use shortly before the 1914–18 war, on account of the higher efficiency of the straight mechanical gearing. Not much more was heard of the Föttinger transformer or torque converter for the next twenty years or so, until J. M. Voith, of Heidenheim, Germany, realised its poten-

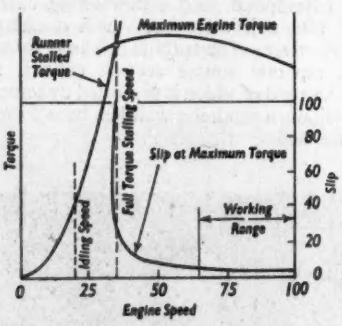


Fig. 8—Performance characteristics of hydraulic coupling

tialities for coupling a diesel engine to the road wheels of a locomotive.

A complete hydraulic transmission for a locomotive consists of a torque converter followed by one or more hydraulic couplings or additional converters.

The Torque Converter.—The torque converter consists basically of a centrifugal pump and a hydraulic turbine. An arrangement of a torque converter is shown in Fig. 5, and Fig. 6 shows the relations between the input and output torque and the efficiency of a torque converter as functions of the speed of the output shaft, with the primary speed and torque remaining constant. The torque multiplication is determined by the design of the impeller and turbine wheel, and is usually between 5 and 9.

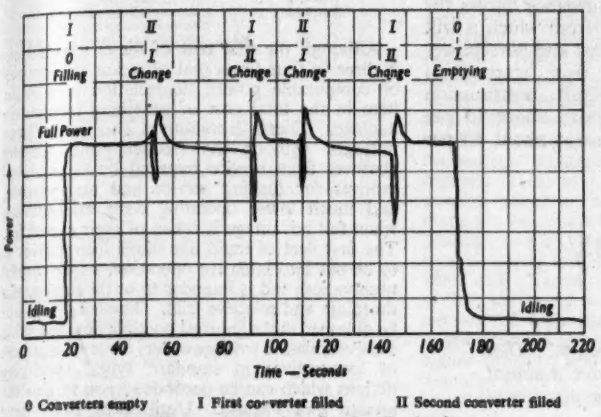


Fig. 9—Filling and emptying of hydraulic circuits

It will be seen from the diagram that the torque multiplication is a maximum when the output shaft is stalled, i.e. when the output speed is zero, and that the output torque falls quite automatically on a hyperbolic curve as the output shaft speeds up. This is a valuable characteristic of this form of transmission as almost all loads require this form of effort under conditions of acceleration. It follows, therefore, that the hydraulic torque converter is an infinitely variable torque ratio transmission. Within its designed range of operation it will rapidly and automatically balance the speed of the load to suit the resistance encountered in moving that load, while allowing the diesel engine to develop its full power continuously.

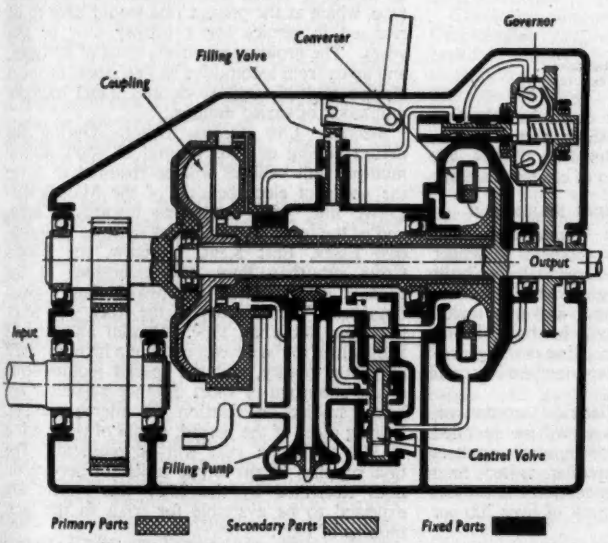


Fig. 10—100 b.h.p. hydraulic transmission, type L.22

The Hydraulic Coupling.—The hydraulic coupling, shown in Fig. 7, consists of two similar rotating members, each having straight radial vanes.

The characteristics of a coupling are shown in Fig. 8. The input and output torques are always equal, i.e. there is no torque multiplication in a coupling, since the outward acceleration of the fluid by the impeller is always equal to the inward deceleration of the fluid by the turbine.

The couplings used in the transmissions have been developed from the original hydraulic coupling known as the Vulcan coupling for which a patent was taken out in 1905 by Dr. Föttinger's firm—Stettiner Maschinenbau, A.G., which was the proper title of the Vulcan Works in Stettin. The Vulcan coupling never appears to have been employed commercially until the 1920s, when it was widely used by the late Dr. Bauer in conjunction with his Bauer-Wach exhaust steam turbines. It is interesting to reflect how these two inventions, the Föttinger transformer and the Vulcan coupling, which were both developed for marine use, are so widely used to-day on diesel locomotives.

The change over from one transmission ratio to another in the Voith hydraulic transmission is effected by the filling and emptying of independent fluid circuits. The emptying of one circuit and the filling of the other is arranged to overlap so that there is no loss of tractive effort. Fig. 9 shows the rapid filling and emptying of two converters in a typical two-circuit transmission. It will be seen from this curve that the drop in the power curve is of extremely short duration (of the order of one second) and is succeeded by a short increase in output which compensates for any loss.

An arrangement of a small two-circuit, 100 h.p. transmission is shown in Fig. 10. This transmission consists of one converter followed by one coupling, and is suitable for a transmission of 100 h.p. and is used in underground mines locomotives. Fig. 11 shows the performance curve for this type of transmission. From this figure it will be seen that while in the converter range the engine speed and horsepower is practically constant, whereas in the coupling range the engine speed and power varies in a similar manner to that found in a mechanical gearbox. There is, however, a gain in efficiency in this range compared with that obtained while in the converter range.

The largest Voith transmission in production to-day is the L.306, which is designed to transmit rather more than 1000 b.h.p. It will be seen from Fig. 12 that this transmission consists of three torque converters. The primary shaft 3 is driven by the diesel engine through the step-up gears 1 and 2. These speed-increasing gears are fitted to ensure that the hydraulic components are maintained at their smallest economic size by operating them at a speed of approximately 3000 r.p.m. In this connection it must be remembered that the power transmitted by torque converters varies as the

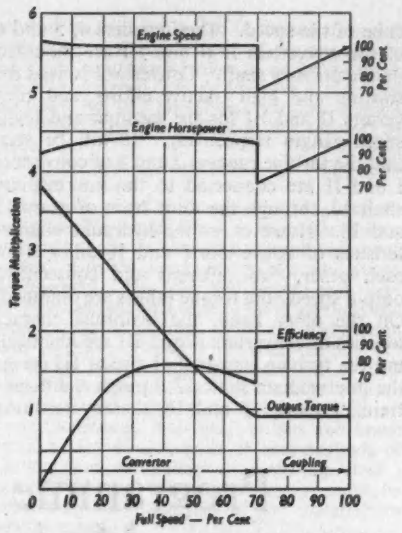


Fig. 11—Performance characteristics of 100 b.h.p. hydraulic transmission, type L.22

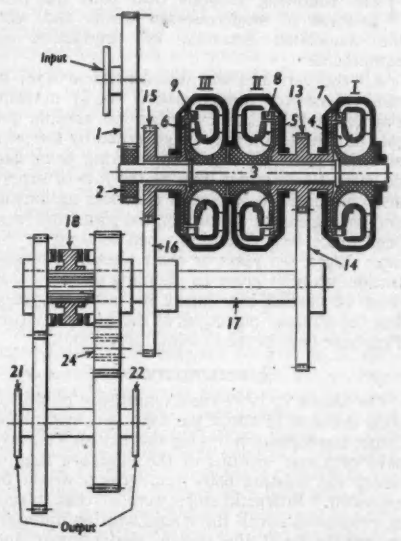


Fig. 12—1000 b.h.p. hydraulic transmission, type L.306

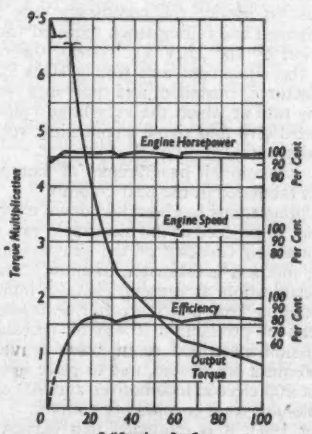


Fig. 13—Performance curve of 1000 b.h.p. hydraulic transmission, type L.306

cube of the speed. The impellers 4, 5 and 6 of the converters I, II and III are mounted on the primary shaft. Converter I is used for starting and high tractive efforts, and converters II and III for the medium and high-speed ranges respectively. It will be seen that the turbine runners 7 and 8 of converters I and II are connected to the intermediate shaft 17, through the same train of gears 13 and 14. However, as the hydraulic characteristics of converters I and II differ from each other, two different and consecutive output speeds and torque ranges are obtained. On the other hand, the hydraulic characteristics of converters II and III are identical, but the turbine runner 9 of circuit III drives the intermediate shaft 17 through a different train of gears, 15 and 16, thereby resulting in a third speed and torque range for converter III following directly on converter II.

By this means the transmission maintains a constantly changing torque and speed characteristic over the full working range. The shaft 17 transmits power to the output flanges 21 and 22, through the reversing clutch 18. Reversing is obtained by interposing an idler pinion 24, in one train of gears.

Fig, 13 shows the performance curves for this type of transmission, from which it will be seen that the engine speed and horsepower are practically constant from starting to full speed and the overall transmission efficiency at all speeds above about 15 per cent is practically constant at about 80 per cent.

Programme for Railway Modernisation

Last week there was issued a White Paper on "Proposals for the Railways." That White Paper is reviewed on page 605 of this issue. Below is reproduced almost in full an appendix from it giving details of the programme of modernisation of the railways under the Plan.

THE following sections deal with the programme of modernisation works and with the associated schedule of production of equipment.

All the activities are interdependent and, in most phases of modernisation work, overlap. For example, in an electrification scheme the rate of completion may be governed by the pace at which civil and signal engineering work can be carried out, rather than by the rate of supply and committal to service of electrical equipment and rolling stock. Naturally, the plans that have been made lack definition when referred to the later stages, ten years or more ahead. Concentration has been given to planning the work that must be carried out during the next six years. But the ultimate objectives of the Modernisation Plan have been borne in mind throughout.

Electrification

On March 6, 1956, the Commission published their decision to adopt the 25kV a.c. system for future electrification throughout British Railways save on those sections of the Southern Region where the existing 660V d.c. system would be extended. Energetic steps were at once taken, in conjunction with the manufacturing industry, to put in hand the design, development and supply of the new equipment required, and notification was given to the Central Electricity Authority concerning the first requirements for the supply of power.

A preliminary programme for the completion of all the electrification schemes contained in the Plan has been worked out. This takes into consideration the time that is required to develop and test in service the completely new forms of equipment and rolling stock required for electrification by the 25kV a.c. system, the rate at which the equipment and rolling stock can be manufactured, installed and put into service, and the rate at which the very large volume of associated civil and signal engineering work can be carried out.

The provisional programme of completion dates is tabulated in the next column,

The programme has been laid down to provide for work to proceed at the most rapid rate which the combined capacity of the railways and of private industry is estimated to allow. The rate of electrification at present planned builds up to a peak in 1962 and thereafter decreases. At the peak of production it will be necessary to commission electrified single track at the rate of 1000 miles per annum, and to place in service at least 200 electric locomotives and 900 electric multiple-unit train coaches per annum.

After 1962, it is estimated that capacity will be available for undertaking electrification works in addition to those provided for in the Plan. The Commission have under consideration proposals by which advantage could be taken of this, so as to exploit to the full the great operational and economic benefits the railways will derive from a wider extension of electric traction.

Provisional Electrification Programme

London Midland Region (25kV a.c. system) :	
Slade Lane Junction (Manchester) to Wilmslow (test section)	Mid 1958
Manchester to Crewe	Mid 1959
Remainder of main line electrification, Euston to Manchester and Liverpool	(Tentative) 1967
Eastern Region (25kV a.c. system, except where otherwise shown) :	
Shenfield–Southend (1500V d.c. system)	January, 1957
Colchester–Clacton (25kV a.c. system (test section)	Mid 1958
Conversion of Liverpool Street, Chelmsford, Southend sections from d.c. to a.c. system	Mid 1959
Enfield–Chingford, Hertford and Bishop's Stortford	Mid 1960
London–Tilbury and Southend	Mid 1961
Chelmsford to Ipswich and coastal branches	By stages up to 1965
King's Cross, Moorgate, Hitchin and Letchworth	(Tentative) 1962
Eastern and North-Eastern Regions (25kV a.c. system) :	
King's Cross–York and Leeds	(Tentative) 1970
Scottish Region (25kV a.c. system) :	
Glasgow suburban :	
Stage I, North of Clyde	1960
Stage II, South of Clyde	1962
Southern Region (660V d.c. system) :	
Extension of electrified lines to Ramsgate, Dover, Folkestone and Hastings (via Ashford)	1962

The Locomotive Building Programme

Steam Locomotives.—The Commission have already announced that no new express passenger or suburban steam locomotives will be built after the 1956 building programme. A further eighty-four heavy freight and sixty-one mixed traffic steam locomotives will be built during 1957 and early in 1958, completing existing programmes. Few, if any, steam locomotives will be built thereafter.

Electric Locomotives.—Electric locomotives, now in the development stage, will be supplied by manufacturers during 1958 in small numbers in prototype form. Thereafter, after final designs have been settled, production will rapidly be stepped up to reach the peak of over 200 per annum during 1961.

Diesel Shunting Locomotives.—There are at present in use on British Railways 510 diesel shunting locomotives. This total will be increased to about 900 locomotives on completion of authorised programmes in 1958. The Plan envisages a further 1200 shunting locomotives being required to replace the 1500 steam shunting locomotives which will still then remain. Programmes now in preparation provide for the supply of about 700 diesel locomotives, during the period 1958–62, and if possible the rate of supply will be accelerated. By 1962 the plans provide for about 1600 diesel shunters in service.

Thereafter, the remainder of the diesel locomotives required to dispense with steam shunting altogether will be obtained as rapidly as circumstances will allow. Considerable savings will flow from this transformation. Apart from instant availability offered by the diesel shunter, and the small loss of operating time required for servicing, it can be operated by one man.

Main Line Diesel Locomotives.—Orders have been placed for 174 main line diesel locomotives at a cost of £11,400,000. Delivery will commence towards the end of 1957. These have been allocated to Regions as follows :—

London Midland	65
Eastern	80
Western	14
Southern	15

Although the first cost of diesel locomotives is three to four times that of steam locomotives of comparable power, depreciation is a small item in the total cost of providing locomotive haulage. Diesel locomotives can cover large mileages without the frequent and lengthy absences from service required by steam locomotives for fuelling service and maintenance, and much lower operating costs are possible when full advantage is taken of their capacities. The first fleet of main line diesel locomotives is to be put into intensive operation, under careful observation, and is intended to be the subject of a thorough and selective trial. Essential data will be obtained in the shortest possible time to enable the Commission to place orders for large numbers of locomotives in standard types, specifying designs which can be depended upon to give the service they require. Until these trials have been completed, the Commission intend to restrict further orders to comparatively small numbers. By 1961, however, it is expected that annual orders will reach a level of about 200 locomotives and that this rate of production will be required to continue each year for an indefinite period.

The Carriage and Wagon Building Programme

During the period of seven years ending in December, 1962, it is expected that a total of about 20,000 coaching vehicles of all kinds will be constructed, replacing about 25,000 existing vehicles, including all the remaining wooden-bodied coaches, some 14,000 in number. The programme is based upon a substantial increase in the rate of replacement of vehicles of obsolete type, which at the present rate would have to be retained in service for a further four or five years. The programme covers units of all types, and apart from locomotive hauled stock, includes electric multiple unit stock and diesel multiple unit stock of varied designs.

Multiple Unit Electric Stock.—During the period ending in 1962 a total of 4500 electric multiple unit vehicles will be required to cover the needs of electrification of the Manchester-Crewe line, with extensions towards Euston, and of the other electrification schemes in South-east Essex, East Kent, Glasgow, the King's Cross suburban lines, and extensions of the existing electrification to Ipswich and coastal branches. The majority of the stock will be of the open suburban type. Special attention is being given to the development of a high standard of riding quality, and the special requirements of the suburban or short distance passenger are being studied in relation to internal design. During most of the period, a rate of production of 900 vehicles a year will be required. The first supplies of prototype units for service on lines electrified by the 25kV a.c. system are expected to be available for trials in the later months of 1957.

Multiple Unit Diesel Vehicles.—The Modernisation Plan envisaged 4600 vehicles of this type being placed in service. Contracts have already been placed in railway shops and with manufacturers for 2401, which are expected to be completed in 1958.

Table I gives details of the services to which these vehicles have been allocated. Two hundred and seventy-two vehicles are already in service. It is anticipated that the remainder of the 4600 vehicles covered by the Plan will be in service before the end of 1961.

The trains described, with the exception of those required for the London-Hastings service, are built to a number of basic designs, and are fitted with under-floor engines and mechanical, electric or hydraulic transmissions.

The internal design of the cars is adjusted to suit local requirements.

Development work is now proceeding on two further types of diesel trains of radically differing characteristics, one for use in high speed, luxury,

TABLE I—*Diesel Multiple Unit Vehicles*

Allocation for period ending December, 1958

Operating Region	Type and service	Motor cars	Trailer cars	Total
	Inter-city :			
Scottish ...	Glasgow-Edinburgh	31	15	46
Western ...	Birmingham-Swansea	12	6	18
Scottish ...	Glasgow-Ayr-Girvan	44	22	66
				130
	Suburban :			
Western	Bristol area	20	10	30
	London area	28	14	42
	S. Wales area	30	11	41
	Cardiff area	90	43	133
	Birmingham area ...	36	18	54
				300
	Cross country or branch :			
Eastern	East Anglia	62	62	124
	Norwich	37	37	74
	Lincoln	37	37	74
	Cambridge	25	25	50
	Colchester	19	19	38
	West Riding ...	48	—	48
	Newcastle - Middlesbrough-Carlisle	44	42	86
North-Eastern	Hull area	31	31	62
	York - Leeds - Scarborough	78	78	156
	County Durham ...	62	62	124
	Other N.E. schemes ..	63	39	102
London Midland	North Wales	7	7	14
	W. Cumberland ...	18	14	32
	Bury-Bacup	7	7	14
	Birmingham schemes	82	58	140
	Manchester schemes	206	117	323
	Derby - Leicester - Nottingham	34	17	51
	Birmingham area ...	36	18	54
Western	Bristol	56	9	65
	London	10	5	15
	S. Wales	62	29	91
	Other schemes	31	21	52
				1789
	Diesel-electric:			
Southern	London-Hastings ...	—	—	146
	Hampshire	—	—	36
				182
	Grand total	—	—	2401

main line services, and the other for operation in lightly used branch lines where economy of running cost is the prime consideration. The high speed luxury train will run between large cities and will contain all that is best to offer for the comfort and amenity of the passenger. It is expected that a few of these trains will be in operation towards the end of 1958, and their further introduction will depend upon the way in which they are received by the travelling public.

A light rail car, powered with a single underfloor diesel engine, and designed to achieve maximum economy in running and maintenance costs may prove of great value, since some rail services in rural areas, at present running at a loss greater than can be counter-balanced by the use of present types of diesel trains, may thereby be preserved. The Commission intend to carry out extensive practical trials with such vehicles in a number of rural services throughout the country, giving particular attention to the changing needs of the country passenger, and to economic operation in all its aspects. It is hoped to commence the trials in 1957.

Locomotive Hauled Stock.—Whatever may be the trend in favour of multiple unit express trains, the need will continue to haul long distance traffic by locomotives, either electric or diesel, and for many years, steam. During the period 1956–62, about 7700 gangwayed locomotive hauled coaches for main line operation will be built. New standard coaches are being developed which will provide very much improved passenger accommodation, in which special attention has been paid to smooth riding, comfortable seating, attractive decor, heating, ventilation and lighting, reduction of noise, improved toilet facilities, and cleanliness. It is expected that vehicles of improved design will begin to appear during 1957.

New and improved types of restaurant and buffet cars are being developed, and it is intended that a five-year programme of replacement of the present stock will commence towards the end of 1957, involving the construction of a fleet of 600 vehicles. During the 1956–62 period a programme of construction will be undertaken covering a further 2800 vehicles of various types, classed as coaching vehicles, such as luggage vans, fish vans, mail vans and the like.

Mineral Wagons.—The plan provides for the replacement of all remaining low capacity timber-bodied coal wagons by all-steel wagons of higher capacity. Existing contracts for manufacture of the 16-ton steel wagon will by the end of 1957 have provided British Railways with a total fleet of 320,000 of this type. About 190,000 low capacity timber-bodied wagons will remain. These will be replaced by 24½-ton steel wagons to the extent that traders' terminal facilities will permit, but it has become apparent that their use will be limited during the period of the Modernisation Plan. It is, therefore, necessary to construct a wagon of slightly lower capacity, 21/22 tons, to give as wide a use as possible. Such a wagon is now being designed. Plans are being made to build numbers of high capacity wagons, largely of the new 21/22-ton type in a long term programme commencing in 1958, with a target of the complete replacement of the 190,000 old wagons by 1966 by a reduced number of high capacity wagons. Similarly, wagons for the transport of iron ore will be of higher capacity, and where it is economic and desirable to do so in the interests of the trader and British Railways, special wagons with high axle loading and with limited route availability will be built to be operated in circuit working.

General Merchandise Wagons.—Under this heading, wagons will be built in annual programmes to meet the changing needs of industry, and in addition to vehicles of the standard types, wagons of a specialised character are being, and will continue to be, designed for the carriage of specific types of traffic, e.g. cement in bulk, steel strip coil, palletised consignments, containers. The plans provide for a total of 255,000 wagons of all types to be built during the period 1956–70.

Containers.—The design of containers is being reviewed, and it is expected that there will be considerable development in this type of traffic. It is probable that an average of 5000 containers a year will be constructed during the period 1956–62.

Continuous Brakes on Freight Trains.—The Commission have decided to adopt the vacuum brake as standard for freight rolling stock, and to fit brakes to all stock as quickly as possible. The rate of fitting is dependent upon a number of factors, notably :

(*a*) The rate at which the necessary equipment can be provided by industry and by railway shops.

(*b*) The rate at which the equipment can be fitted into wagons, and other necessary modifications made.

(*c*) The rate at which the wagons can be released from traffic and moved to the workshops where fitting is to take place.

The operation of freight trains at speeds up to 60 miles per hour entails modifications to various types of wagon apart from fitting of brakes. For example, it is necessary to close-couple all freight stock running at these high speeds, and this will entail the provision of screw type couplings and new buffers. Mineral wagon operation at express speeds requires the larger mineral wagons to be fitted with roller bearings. This will involve the fitting of some 600,000

Year	Fitting to existing wagons	By new building	Total number of wagons to be fitted
1957	25,000	17,000	42,000
1958	47,500	28,000	75,500
1959	47,500	24,000	71,500
1960	47,500	19,000	66,500
1961	47,500	19,500	67,000
1962	47,500	19,000	66,500
1963	47,500	18,000	65,500
1964	47,500	15,000	62,500
1965	47,500	10,000	57,500
1966	47,500	10,000	57,500

roller bearing axleboxes to existing wagons. Arrangements must also be made to provide for the maintenance of the mechanical brake equipment and for testing in marshalling yards and goods depots as well as in works and outstations. Taking all these considerations into account, and having regard to the numbers and varying types of vehicle involved, the programme for fitting continuous brakes to all freight stock has been designed initially to cover a period of ten years, but it is hoped that this period might be reduced, and every effort to this end will be made.

The preliminary programme of fitting is as follows :

Development.—The Commission have recently authorised the establishment at Faverdale Works, Darlington, of a development unit fully equipped to deal with all aspects of carriage and wagon development. This unit will initiate and carry out development on a wide range of carriage and wagon subjects, in some cases in collaboration with industry. It will cover such matters as : (*a*) design and prototype production of new designs of rolling stock and carriage bogies ; (*b*) design and experimental production of improved axleboxes, draw-gear, buffers and brake details ; (*c*) developments of new methods of heating and ventilating of coaching stock ; (*d*) entirely new conceptions which might be inspired by the availability of new materials or new processes.

It is expected that this unit would be able to start its work within twelve months, and will be built up to be fully operative in two years.

Civil Engineering Work

The following paragraphs outline the main features of the work.

Works Associated With Electrification.—The principal works required for electrification are preparation of the track for higher speeds, structural and track alterations at stations and junctions, bridge and tunnel alterations to provide for electrical clearances, and the construction of depots for the new motive power and rolling stock. Work is already in hand on the strengthening of the road bed and extensive re-ballasting and additional relaying of track as necessary on the lines included in the first stages of electrification. Surveys are in hand to determine the details of the structural alterations required to give electrical clearances, and site work, already commenced to cover the early stages, will be a continuing process throughout the spread of electrification.

Other Track Works.—In addition to the track improvement work required on lines to be electrified, similar work must be carried out on other main lines to meet the higher speeds that will be attained by express diesel-hauled trains and high speed multiple unit diesel trains. Goods lines must also be improved to allow for the faster speeds of freight operation made possible by the continuous brake. Orders have been placed for additional heavy mechanised equipment to assist in this work. By 1958 there will be available for service 100 ballast tamping machines and sixteen ballast cleaning machines. Orders have also been placed for four electric rail welders which will be delivered in 1957 and 1958. When these have been received and installed in depots, an extensive programme of installation of long welded rails will be undertaken. With the elimination of the rail joint, track maintenance costs will be reduced, and smoother riding of trains will result.

Building, Structural and Other Heavy Construction Work.—A wide range of work is to be undertaken, apart from that associated with electrification.

The planning of building work is involved in character, and must be built up in detail, item by item. Hence it is not possible at this stage to give a comprehensive picture of the whole of the work covered by the Plan. Building work will include station reconstruction and improvements, the construction of new depots for diesel locomotives and multiple unit trains and other rolling stock, and the provision of new freight terminals. Much of this work is already in hand. Important station reconstructions have been authorised at Peterborough, Plymouth, Banbury and Cannon Street and many other schemes are in the design stage.

New maintenance depots for diesel multiple unit trains are authorised at Lincoln, Norwich, Stratford, Glasgow, Ayr, Edinburgh, Darlington, St. Leonards, Tyseley and Cardiff (Canton). A model layout of a diesel train depot has been

evolved, and details have been issued for the guidance of designers. Considerable changes are foreseen in the design and layout of freight terminals to facilitate interchange of goods and containers from road to rail, and the development of model designs is under close study. Over £14,000,000 has already been authorised for the construction of new marshalling yards, which, for the civil engineers, involve heavy earthwork and extensive track laying. The most important works so far authorised are those at Ripple Lane (Barking), Millerhill (Edinburgh), Thornton (Fife), Perth, Temple Mills and Port Talbot.

A heavy programme of bridge reconstruction is contemplated, to overcome arrears which still remain as the result of the war, and the steel shortages which followed. The plans are designed as far as possible to carry out bridge renewals on lines to be electrified, in advance of the opening of the new services, so as to avoid placing speed restrictions on them at a later date, necessary during the period of reconstruction.

It is expected that the level of expenditure on these works will build up to a level of about £25,000,000 a year by 1959 and will subsequently be maintained at this level until the later stages of the Plan have been reached. In achieving this output, considerable assistance will be required from consultants and contractors, and they are already being employed to an ever increasing extent.

Signal Engineering Work

The following paragraphs outline the main features of the work.

Work Associated With Electrification.—The electrification of a line of railway has a very considerable effect on the requirements for signalling. There is not only the necessity to take measures to avoid electrical interference and physical obstruction to the sighting of semaphore signals, but in addition there are the changes necessary to cater for the increased density and speed of traffic which electrification makes possible. For these reasons it is generally the practice to carry out a complete re-signalling of the line while it is being electrified. This involves the provision of track circuiting throughout, the replacement of semaphore signals by a much greater number of colour lights and the centralisation of traffic control at large centres in the interests of labour economy and free traffic flow. The programme of work for signalling is in accordance with the overall time-table for electrification.

Installation of Automatic Train Control.—Plans are being made for automatic train control to be provided on the main traffic routes throughout the country. During the period 1956-62, the following routes will be equipped: London (King's Cross) via Newcastle to Edinburgh. London (Euston) to Glasgow (including Manchester and Liverpool). Edinburgh to Glasgow. London (Waterloo) to Bournemouth and Exeter: London (Liverpool Street) to Norwich.

Signalling of New Marshalling Yards.—Apart from the signalling and communications system required in the yards, the programme allows for the installation of automatic braking equipment to control the speed of wagons during gravity shunting. Considerable developments are anticipated in this field, in the provision of automatic control devices for the brakes, so eliminating human error, and enabling shunting to continue in fog and other adverse conditions.

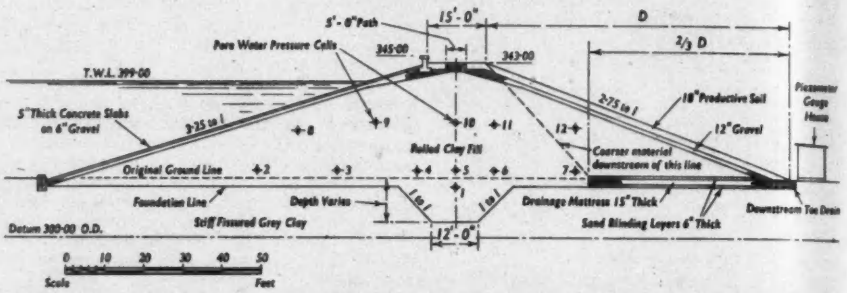
Other Signalling Modernisation Works.—Work programmed under this heading covers the provision of track circuiting and colour light signalling in a large number of localities, where the existing signalling systems are inadequate to deal efficiently with the higher speeds and frequency of the future services. In addition, the schemes provide for more economical operation by the replacement of numbers of outmoded manually operated signalboxes by single modern power boxes.

Telecommunications.—The telecommunications system network of British Railways is inadequate to deal with modern conditions. The plans provide for an automatic "on demand" service between all important points. Many years will elapse before the work can be completed. A commencement will be made by the concentration, in important localities, of several exchanges into one automatic exchange, and by increasing telephone route capacity where most needed. Intense study is being given to the extended use of teleprinter services, and of the application of electronic devices to the gathering, storage and presentation of control information.

It is expected that the level of expenditure on signal engineering work will build up to about £12,000,000 a year by 1958 and thereafter continue at about the same level. This will require a considerable expansion in the output of signalling manufacturers and contractors, who are aware of the need.

Homogeneous Earth-Fill Dam of the Foxcote Reservoir

The first stage of the Bucks Water Board's River Great Ouse supply scheme was completed about three years ago. The second stage of the scheme has just been finished and, although of relatively modest size, is of interest because its main work, the Foxcote dam, has been constructed entirely of clay, to form a homogeneous structure, and not with the customary central core. The Foxcote dam, and a similar small dam recently built as a subsidiary dam for the reservoir of the Hanningfield scheme in Essex, are believed to be the only ones of their kind built in this country in recent years. That is to say they are probably the only homogeneous dams built according to scientific principles, for doubtless such dams have been constructed in the past, on an empirical basis, before the disciplines of soil mechanics were in use.



Cross section of the homogeneous embankment of the Foxcote reservoir, which is built with rolled clay filling material. Twelve measuring cells for pore water pressures are shown; twelve more have been installed at a second cross section

The Great Ouse supply scheme consisted in its first stage of an intake from the river, with a pumping station leading to a small balancing reservoir and treatment works; then a second pumping station at the treatment works led off to the supply mains which give bulk supplies to various neighbouring undertakings. Disused gravel pits close to the intake were utilised for storage of water, which could thus be drawn off at times of excess demand and replenished at times of high river flow. The second stage allows greater use of this principle by providing additional storage in the valley of a small side stream, the Foxcote brook. The Foxcote reservoir is filled by pumping water from the main river reaching it through the balancing reservoir. There is, in fact, a small yield from the Foxcote brook itself. With both stages of the scheme complete, the storage available is 145 m.g., 107 m.g. in the Foxcote reservoir and 38 m.g. in the gravel pits. The maximum rate of abstraction from the river is 3 m.g.d.

The dam is about 30ft high and 850ft long; it contains about 43,000 cubic yards of clay fill. The site consists mainly of a stiff fissured grey clay, 40ft to 50ft thick, classified as relatively heavily over-consolidated, and with a high liquid limit. With such material fairly high initial strengths can be obtained when an embankment is built, but subsequent softening, extending over several years, reduces the strength very considerably. The explanation given is that negative pore pressures can be expected to develop in "over-consolidated" clay during excavation and compaction in an embankment. Subsequently, it would tend to absorb water, and swell in the process, into the voids left by incomplete compaction, this phenomenon causing the softening. A record of pore pressures is thus of value in confirming the behaviour of a dam of this kind; the installation of pore pressure gauges at Foxcote is detailed in the accompanying cross-sectional diagram of the dam; other constructional points such as the cut-off trench and downstream drainage arrangements, are also shown.

Design of the dam was based on the conventional $\phi=0$ analysis, assuming a shear strength of 400 lb per square foot, giving a safety factor of at least unity. Undisturbed samples of the clay gave a minimum shear strength in unconfined compression tests of 1000 lb per square foot. A dry density of about 95 lb per cubic foot, a liquid limit averaging 65 per cent, and an optimum moisture content of 27 per cent, were also determined, and a permeability of about 10^{-7} centimetres per second was established for the compacted clay.

Strict control was operated on the material used in the embankment, excessively silty or sandy material being rejected, and any sandy material accepted was only used on the downstream side. Moisture content and compaction of the fill were also strictly controlled. In wet weather embanking was restricted and in dry weather watering of the fill became necessary. Compaction was obtained using bulldozers, spreading the clay in thin layers and rolling with a wobbly wheel and flat roller. Particular care was taken that a day's fill was compacted and sealed against possible rain. The maximum height by which the dam could be raised during any one month was 4ft.

The cut-off trench had a depth of 8ft to 10ft. This depth was exceeded only for a length of 75ft on the right bank where silty material revealed by the borings was struck, and this length, which was taken to a maximum depth of 16ft, required timbering. Filling of the timbered portion of the cut-off trench was the slowest process since this necessitated hand placing and ramming.

At the left-hand end of the embankment the cut-off consisted of a 3ft concrete wall made with high-alumina cement concrete and above part of this the concrete overflow weir was constructed. The important concrete works in contact with the clay have a 3in skin of high-alumina cement concrete, because the clay is aggressive to concrete; in some cases this protective concrete was used in the form of precast slabs, which eliminated shuttering.

The work at Foxcote reservoir was carried out for the Bucks Water Board; the consulting engineers were Messrs. Binnie, Deacon and Gourley. The main contractor was Richard Costain, Ltd.

Air Filtration Material.—Air Control Installations, Ltd., Ruislip, Middlesex, is now supplying in this country filters packed with "Amer-glas," manufactured by the American Air Filter Company. The medium consists of fine glass fibres, interlaced and held together by a thermoplastic bond. Each fibre is coated with a special Viscosine that forms an adhesive film to hold collected dust. The Viscosine used in "Amer-glas" media is noninflammable and retains its consistency at temperatures below 150 deg. Fah. (65 deg. Cent.). The fibres are packed progressively more closely in the direction of air movement, so that the whole depth of the pad participates evenly in the extraction of dust. The material is supplied assembled into a casing ready for installation into most standard filter frames.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

"NEVER BE SHORT OF LABOUR"

SIR,—The bogey raised by Mr. Wright is not a new one. One can well imagine the Luddites asking of what use would be the new machines if the unemployed artisans themselves could not even buy the cheaper goods made on the machines. That this was too gloomy an outlook needs no stressing to-day. Few would care to deny that—in the long run—increased productivity results in a higher standard of living for all. The problem, then, is to accommodate the short-term stresses and strains. If manufactured goods are to be sold more cheaply as a result of automation, labour costs must be reduced. This means either shorter working hours at the same hourly pay, or the employment of fewer men in the factory concerned.

Neither of these alternatives would present a problem if price reductions became general throughout industry. The worker on short time would earn less, but his money would buy more; the additional leisure being a useful bonus. Again, a general reduction in the cost of manufactured goods would leave so many people better off that there would be an increased demand for goods and services, particularly luxuries which are not usually produced by automatic means. Thus, any labour displaced by automation would be re-absorbed as a result of the greater demand for the good things of life. This, of course, is why the early predictions of disaster have proved unfounded. If the cake grows bigger and the number of slices remains the same, it would be an absurd division which resulted in any individual's share becoming smaller than before. On the other hand, temporary maladjustments and crises have occurred in the past and their recurrence in the future cannot be ruled out. If part of the cake is grabbed by the dog or left to go stale, the outlook may be very different.

It would seem, therefore, that Mr. Wright's problem is not one resulting from automation, or, indeed, from increased productivity at all, but from inadequate distribution of the product.

E. G. SEMLER,
B.Sc., A.M.I.Mech.E.,
Editor, *Automation Progress*
October 23rd.

AIRCRAFT PROCUREMENT

SIR,—In your reporting of my recent lecture, "The Importance of Time in Aircraft Manufacture," I notice a small point which I think might be misunderstood.

In the line commencing "The Air Commodore pointed out that engines were even more expensive, slow and difficult to develop ..." I indicated that while engines were expensive and difficult to develop, the complexity of the modern aircraft was such that it was taking about as long, and even longer in some cases, as the engine; and if the aircraft had a protracted development this also reflected on the engine (but was not the engine's fault) in extending the latter's development period.

F. R. BANKS
Bristol Aeroplane Company, Ltd.,
October 23rd.

Literature

Television Engineering; Principles and Practice. Volume II; Video-Frequency Amplification. By S. W. AMOS and D. C. BIRKINSHAW. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 35s.

THIS, the second of a series of four textbooks on television engineering, will probably be of greater interest to the general electronic and radio engineer than the other three volumes, since its subject matter—wide band amplification—is of constantly recurring importance.

The text is based on an internal B.B.C. manual, and shows the clarity and precision so often found in works based on teaching notes. The only criticisms which can be reasonably levelled are: first, an irritating interpolation of mathematical appendices throughout the book and, secondly, an uncertainty concerning the level of knowledge required of the reader: for example, the operator "j" is used without any introduction, yet the equations concerning the charge or discharge of a capacitor in a resistive circuit are set up at great length. However, these are trivial comments on a useful and workmanlike book.

Part I, which is a general introduction, discusses the necessity for good amplitude and phase characteristics in video amplifiers, and defines some of the picture distortion commonly encountered. It is excellently illustrated by a number of photographs, and concludes with an appendix on Test Card C and its use in setting up a television receiver. Part II concerns itself with the h.f. considerations of video frequency amplification and treats of fundamental circuitry. The *R-C.* coupled, shunt-inductance and series inductance circuit each receive separate chapters, followed by a chapter on feedback. A most useful chapter on the pass-band-gain product and the figure of merit of a valve leads on to a discussion of amplifying stages connected in cascade, showing the addition of various circuit responses. Distributed amplifiers are dealt with very briefly, and this section concludes with a chapter on phase equalisers, describing the use of static elements in improving phase characteristics. Part III, on l.f. considerations, treats largely of various coupling and decoupling circuits, showing how the correct choice of decoupling components can have a positive effect in improving circuit performance. There is a brief chapter on the design of a d.c. coupled circuit. Part IV, on feedback in video frequency amplifiers, could have been largely excluded since it covers ground thoroughly explored in many other text books. However, its treatment is clear and terse and aligned particularly to the problems of the video amplifier. The final part of this volume is concerned with noise, its origin in individual components and its effect on amplifying chains.

For the general electronic engineer with a modest mathematical equipment, this book should prove useful: to the specialist it will be inadequate, particularly since the Bibliography is very brief. Its main value will be to the student of City and Guilds IV and V standard, who will benefit considerably from a study of the text.

Aircraft Gyroscopic Flight Instruments. Sixth edition. Sperry Gyroscope Company, Ltd., Brentford, Middlesex. Price 6s.

AFTER a prefatory page on the need for instruments to inform the pilot of an aircraft of his attitude, this book proceeds to the principles of the gyroscope. The fact of precession is taken for granted, but a qualitative justification of this phenomenon is attempted in two pages of diagrams credited to Professor G. P. Meredith. These, however, are little more than a guide to which way precession will appear; nowhere is it made clear why a torque acting on a rotor produces, not acceleration, but velocity.

Once the gyroscope is taken for granted, however, a lucid detailed account of the functioning of actual instruments, illustrated generously with photographs, diagrams and examples, is at the reader's disposal. The simpler air-driven rotors are taken first, but electric drives and erection systems are adequately covered. The various causes of errors in friction-free gyroscopes are explained in detail. On electrical theory the text is particularly pleasing, the appendix on the flux valve detector unit being exemplary; it is, perhaps, surprising to note that the output of this hardly alternates in high speed flight, due to "the stable straight flight path of jet aircraft."

A valuable aspect of this edition—the last was published in March, 1952—is the opportunity to study some of the modern information presentations that have previously been discussed mainly in periodicals and brochures. The zero reader is described and the behaviour of its computer outlined, and then the remote gyro is introduced. The instruments peculiar to the Sperry integrated system, i.e. the compass indicator, the horizon flight director, and the pictorial deviation indicator are illustrated and explained.

Foundations; Design and Practice. By ELWYN E. SEELYE. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 128s.

THIS treatise, written by an American consulting engineer, resembles a handy reference for all foundation problems. The material is presented with a terse, subdivided text, and profuse diagrams, amounting almost to a diagrammatic explanation, with a few definitions, broad classifications, tables of data, and equations, added to it. Examples and conditions refer to the United States throughout. Field problems are presented in juxtaposition to the corresponding design information.

The scope of the subject matter is very wide and does, indeed, seem to cover foundation design and practice comprehensively. Soil mechanics, costs, specifications, constructional methods, embankments and pavings, dams and reservoirs, and field practice are amongst the subjects dealt with under the principal subject headings. More detailed explanations include such topics as cathodic protection, wood preservation and waterproofing. Many of the chapters end with a section called "red lights," where warnings of possible snags are briefly given.

Metallurgical Topics

Internal Pressure Tests on Steel Cylinders

TESTS under multiaxial stress have been made by A. Krisch[1] on five carbon steels having carbon contents of 0·04 to 0·2 per cent in the normalised and in the artificially aged conditions. The tests were carried out on hollow-bored test pieces (O.D. 29mm, I.D. 24mm) under direct longitudinal stress and simultaneous internal pressure, and the characteristics of the fractures were studied. The 45mm diameter bars from which the test pieces were made were strongly segregated at the centre and showed a square "ingot pattern," but the tubular specimens, on which analyses were made, were outside the segregated region. Before the test pieces were prepared the bars were normalised from 930 deg. Cent. and some specimens were artificially aged by overstraining 5 per cent in torsion and heating for half an hour at 250 deg. Cent. The composition of the steels together with average results of tensile and impact tests were made at a position in the bar corresponding to that of the tube wall (Table I).

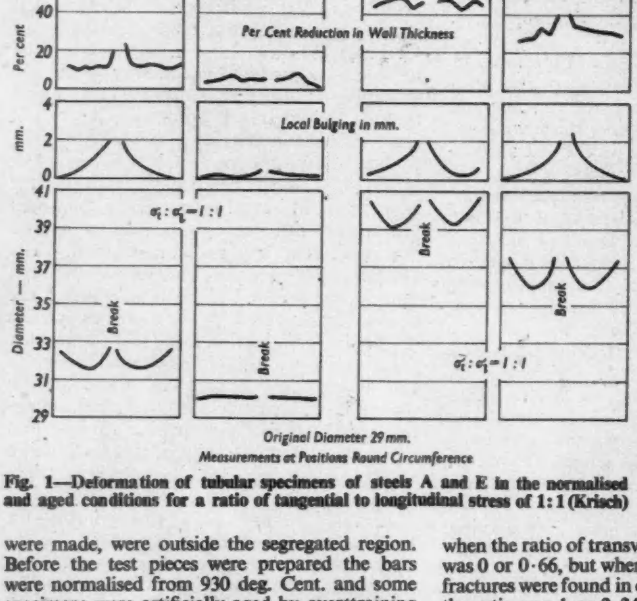


Fig. 1—Deformation of tubular specimens of steels A and E in the normalised and aged conditions for a ratio of tangential to longitudinal stress of 1:1 (Krisch)

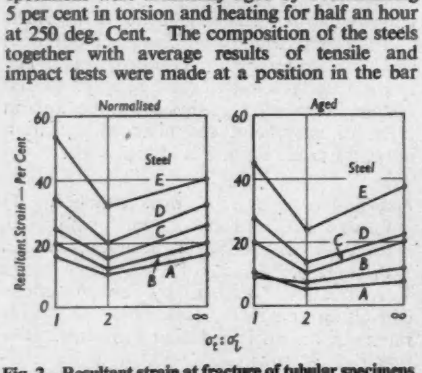


Fig. 2—Resultant strain at fracture of tubular specimens (Part of Krisch's diagram)

The ratio of tangential to longitudinal stress ($\sigma_t : \sigma_e$) was varied from nil to infinity. To obtain $\sigma_t/\sigma_e = \infty$ a compression load was applied to balance the tension produced by internal pressure. For a ratio $\sigma_l : \sigma_e = 1 : 1$, a tension of 1000 kg per square millimetre and a hydraulic pressure of 200 kg per square centimetre were required. With the arrangement used it was easy to maintain a definite ratio of tensile stress to hydraulic pressure during the elastic stage, but after plastic deformation set in control was more difficult. With the onset of local deformation after the maximum load was passed it was usually impossible to preserve the correct ratio and the load was held unaltered. A loose bar placed in the tubular specimen served as a packing piece to diminish the volume of oil and reduce the energy released on fracture of the test piece. For ratios of tangential to longitudinal stress of less than 1 all specimens broke transversely with considerable reduction of area. Brittle fractures and mixed fractures, mainly longitudinal but often turning to transverse near the ends, were observed for ratios 1 : 1 and 2 : 1 in several materials especially in the aged condition. Extremes of behaviour for the ratio 1 : 1 were shown by steels *A* and *E* (Fig. 1). The non-ageing steel *E* and one of the Bessemer steels, *B*, always showed a ductile fracture though the amount of deformation was reduced with increase in the ratio $\sigma_t : \sigma_e$ from 0 to 2.

In somewhat similar experiments by H. Bennek, E. Houdremont and R. Mailänder,[2] all fractures were transverse when the ratio of transverse to longitudinal stress was 0 or 0·66, but when the ratio was 0·8 varied fractures were found in different materials. When the ratio was 1 or 2·24 (under internal pressure only) the fractures were all longitudinal, but in the more brittle steels the longitudinal fracture was extended at the ends into transverse cracks.

In the experiments carried out by Krisch,[1] the multiaxial stress condition, defined by $\sigma_v = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}$, did not diverge to an important extent from the uniaxial stress condition due to the greatest principal stress (σ_1), judging by the ratio σ_v/σ_1), which varied only from 1 to 0·87 at the outside of the tube. The internal pressure experiments thus show that even a small departure from uniaxial stress conditions can reduce the ductility of the material. This agrees with the conclusions of A. Kochendörfer and C. Rohrbach,[3] who found that, although it had been held that brittle fracture only occured when the ratio σ_v/σ_1 was 0·7 or less, one of the steels they studied with σ_v/σ_1 equal to 0·86 already showed a considerably reduced capacity for deformation although tested at a temperature of 50 deg. Cent. The conclusion drawn by Krisch was therefore that in structural parts of machines and containers multiaxial stress conditions must be carefully considered since quite a small departure from the uniaxial condition may be associated with a lowering of the capacity for deformation of the material used. Many examples of brittle failure may be due to a state of stress which deviates only slightly from the uniaxial condition.

Application to Pressure Vessels

The rating of the steels with respect to the influence of multiaxial stress in reducing the capacity for deformation at fracture (see Fig. 2) is almost parallel with that given by the transition temperatures in the impact value/temperature curves of these steels (Fig. 3). The relationship between the impact value and behaviour under multiaxial stress has been the subject of many investigations. For example, H. Bennek, E. Houdremont and R. Mailänder[2] concluded from a variety of tests that the significance of the notched-bar impact value extended to a wide range of service conditions involving biaxial or multiaxial stress. In particular, the mode of fracture of cylinders under internal pressure, whether by extension of a longitudinal crack or by shattering into many pieces, is governed by the degree of brittleness revealed in notched-bar impact tests, though this may not affect the pressure/expansion relation up to the yield point. Brittle fracture may occur with decreased deformation and at a correspondingly lower breaking strength in material with a high transition temperature of tough to brittle fracture.

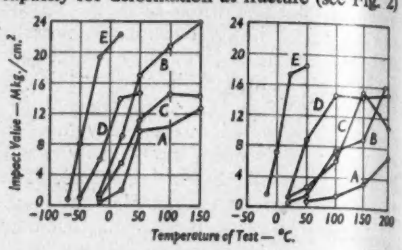


Fig. 3—Impact value/temperature curves of the steels used (Krisch)

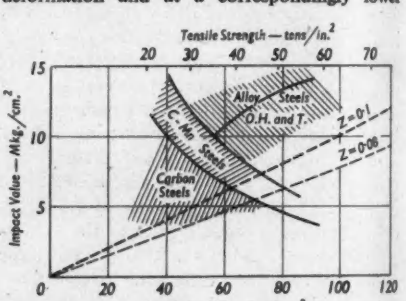


Fig. 4—Diagram illustrating relation between impact value and tensile strength of steels for boilers and pressure vessels (After Mielentz)

The importance of the notched-bar impact value as a safeguard against the brittle fracture of pressure vessels was emphasised in a report by T. N. Armstrong, N. A. Kahn and H. Thielsch,[4] though other factors might be involved in the actual failure. The importance of notched-bar impact value in the construction of high-pressure

TABLE I—*Composition and Properties of Steels*

	Chemical composition, per cent							Yield point, tons per square inch		Tensile strength, tons per square inch	Elongation per cent, L=5d,	Reduction of area, per cent	Impact value DVM test piece, Mkg per square centimetre
	C	Si	Mn	P	S	Al	N	Upper	Lower				
A.—Unkilled Basic Bessemer	0·04	<0·01	0·44	0·120	0·046	0·001	0·016	22·3	21·0	31·2	33·2	63	1·5
B.—Unkilled Basic Bessemer	0·11	0·02	0·31	0·043	0·025	0·001	0·010	18·5	17·8	28·6	35·5	60	8·4
C.—Killed Basic Bessemer	0·20	0·24	0·44	0·067	0·027	0·003	0·011	18·9	18·5	32·6	33·3	59	5·5
D.—Killed open-hearth	0·15	0·25	0·40	0·031	0·030	0·001	0·005	18·3	16·3	28·9	37·5	65	>13·9
E.—Killed open-hearth	0·12	0·09	0·42	0·024	0·028	0·033	0·004	19·9	17·7	26·3	38·7	73	>23·7

vessels has also been referred to by W. Mielentz.[5] He pointed out that it was essential to use only such materials as offer sufficient security against brittle fracture and fragmentation. It was desirable that, in addition to tensile requirements, a minimum angle of bend in the notched-bar test should be insisted upon. On the basis of former experience, a minimum angle of bend of 16 deg. was recommended for high-pressure gas containers. Since angle of bend is not directly measured in an impact testing machine, an equivalent notched-bar impact figure, varying with the tensile strength, must be used. From a study of the relation between notched-bar impact value and angle of bend in steels of different tensile strength, both normalised and quenched and tempered, it was estimated that an angle of bend of 16 deg. would be equivalent to an impact value in kilogramme-metres per square centimetre numerically equal to 0·1 times the tensile strength in kilogrammes per square millimetre of the material concerned. The demand is thus for a minimum impact value which increases with increasing tensile strength. For a given material impact value falls with rising tensile strength, so an increase in impact value can only be obtained by modifying composition or heat treatment. For tensile strengths above 60kg per square millimetre (38 tons per square inch) the use of carbon steel is a doubtful expedient, but by increasing the manganese content, or for higher ranges of tensile strength (e.g., 55 tons per inch and over) by alloying with chromium and molybdenum, especially if the steel is quenched and tempered, the impact value is improved to well beyond the minimum notch toughness required. The value 0·1 for the numerical ratio of impact value (DVM test piece) and tensile strength (kilogrammes per square millimetre) is given by Mielentz as valid for high pressure gas containers, but for boilers and stationary pressure vessels at lower pressures, which present less risk of failure, a lower ratio (0·08) may be sufficient. However, it is necessary to think in terms of the ratio of impact value to tensile strength. The principle of increased minimum notched-bar impact value with increased tensile strength should still hold, but the actual value of the ratio must depend on practical experience.

REFERENCES

[1] *Archiv fur das Eisenhüttenwesen*, August, 1956, page 531.
[2] *Ibid.*, July/August, 1953, page 315; THE ENGINEER, November 6, 1953, page 592.
[3] *Ibid.*, Vol. 26, 1955, page 213.
[4] *Welding Journal*, August, 1952, Research Supplement, page 371; THE ENGINEER, November 7, 1952, page 616.
[5] *Stahl und Eisen*, July 26, 1956, page 971.

Arc-Cast Molybdenum

MR. A. J. HERZIG, President of the Climax Molybdenum Company, of Michigan, Detroit, devoted part of the thirteenth Woodside Lecture[1] to a description of the development of arc-cast molybdenum, tracing the advances made since the beginning of their arc-casting programme in 1937, when the "preparation of large bodies of molybdenum" appeared as the fourteenth item in their suggested list of projects. After the initial melting difficulties had been overcome, the most important problems facing the investigators were porosity due to gas in the metal and brittleness. The gas proved to be, not hydrogen from the sintered molybdenum electrodes as anticipated, but mainly carbon monoxide and nitrogen, and the brittleness was due to films of oxide. Holes were drilled at ¼in intervals in the electrodes and were filled with graphite. The metal produced from these electrodes, arc-melted in a vacuum, withstood an encouraging degree of deformation and was free from porosity. Successive improvements in the plant enabled the Climax investigators to produce by 1946 6in diameter ingots weighing 350 lb. Unlike the molybdenum produced by powder metallurgy methods, which was fine grained, these large arc-cast ingots showed an extremely coarse grain structure, and new problems arose at the ingot-cogging stage. Nevertheless, in the expectation that these would be solved, advance continued in making larger ingots. In 1949 dimensions had reached 12in diameter and 4ft long, and a sound ingot weighing 1000 lb was produced in January, 1951. The yield of sound metal from hammer-cogged or press-forged ingots was disappointingly low as breakdown of the coarse structure was accompanied by extensive cracking. Success was, however, obtained by applying the extrusion process which imposes a uniform compression and so minimises the tendency to crack. Ingot sections were flown to France and were successfully reduced by the Ugine-Sejournet extrusion process in which glass is used as a lubricant. Thereafter, extrusion became the recognised method of breaking down cast ingots. The extruded billets could then be rolled or forged without encountering the difficulties arising from coarse grain size, and arc-cast molybdenum of adequate quality became available by the middle of 1951 as round bar, flat bar and sheet.

It was never in doubt that the largest ultimate use of arc-cast molybdenum would be found in alloys for which molybdenum served as the base metal rather than in the pure molybdenum metal, though it was realised that most, if not all, applications would require developments in design if the full benefit of the new materials was to be secured. During the past few years exploration of the properties, especially the high-temperature properties, of a wide range of molybdenum alloys has been in progress. Wrought alloys having characteristics at high temperatures (850 deg. to 1050 deg. Cent.) comparing favourably with those of the present "super-alloys" and cermets are being produced. In a non-oxidising atmosphere these may have a long life, but in general the tendency to rapid oxidation which affects all molybdenum-base alloys has to be controlled by some form of surface protection. The outstanding problems are now those of fabrication and of protection against oxidation.

The lecture dealt only with broad outlines of development, but the recently published book by Dr. L. Northcott[2] admirably portrays the present position, and shows how the problems of alloying, fabrication and protection are being investigated.

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[1] *Metal Progress*, July, 1956, page 103.
[2] *Molybdenum* (Butterworth's Scientific Publications, 1956.)

Experimental Magnesium Alloys

A PROGRESS report has been issued of the investigation of magnesium alloys undertaken by the U.S. Bureau of Mines.[1] It deals with alloys of magnesium and nickel, magnesium, nickel and manganese, and with magnesium-lithium alloys containing a third metal in addition.

Nickel is insoluble in solid magnesium and separates as a Mg-Mg_2Ni eutectic. Tensile strength is not greatly increased by the presence of nickel; elongation and resistance to corrosion are poor. Directionality of properties becomes more marked as the nickel content is increased. The magnesium-nickel-manganese alloys showed considerable improvement in mechanical properties. Rods containing nickel 4 to 5 per cent, manganese 2 to 3 per cent, extruded at 340 deg. to 540 deg. Cent. had a tensile strength of 20·5 tons to 22·5 tons per square inch with an elongation of 6 to 9 per cent. The higher value of the tensile strength was obtained by extruding at 340 deg. Cent. Variations of extrusion temperature of 450 deg. to 540 deg. Cent. had little effect. The strength of the extruded rod could be increased by swaging at 150 deg. to 250 deg. Cent. to 24·6 tons per square inch (0·2 per cent yield strength, 22·3 tons per square inch), with an elongation of 5 per cent. Unfortunately, the relatively good corrosion resistance of the binary magnesium-manganese alloys was ruined by the presence of nickel. The alloys containing nickel were so low in resistance to corrosion—even room-temperature atmospheric corrosion—that they must be regarded as of no consequence for practical application.

The magnesium-lithium alloys consist of a single solid solution (α) up to 5 per cent of lithium, and of another solid solution (β) when the lithium content exceeds 10 per cent. The β solid solution is notable for showing a high degree of plasticity. A 40 per cent lithium alloy was cast in an atmosphere of helium, and the ingot could be cold-forged down to thin sheet without defect or failure. With increase in lithium from 1·5 to 13·2 per cent the tensile strength of hot-rolled sheet decreased gradually from 13·4 tons to 6·2 tons per square inch, but a 15 per cent reduction by cold rolling raised the tensile strength of the 6 per cent lithium alloy to 16·3 tons per square inch with 6 per cent elongation. No improvements were obtained by adding manganese up to 2 per cent to this alloy. Aluminium additions raised the tensile strength to 18·8 tons per square inch (0·2 per cent yield strength 12·5 tons per square inch) with an elongation of 15 per cent, but a solution treatment at 375 deg. Cent. followed by ageing at room temperature produced no further effect. It was found that ageing would produce beneficial results only when the lithium-rich β solid solution formed the matrix of the alloy, also that the precipitated phase in the aluminium alloys (AlLi) was incapable of producing hardening. However, a cursory examination of magnesium-lithium base alloys containing cerium, antimony or silicon as the third addition revealed precipitation hardening possibilities definite enough to warrant further investigation. Antimony additions of from 0·1 to 2·0 per cent were found to produce a definite and consistent increase in hardness when the solution-treated alloys were aged at relatively low temperatures, and indications were that this condition was stable to a temperature as high as 125 deg. Cent. Experiments with cerium or silicon as the third alloying addition indicated that these elements gave rise to rather more stable ageing effects.

These suggestions require examination in the light of the extensive investigation recently reported by Professor W. R. D. Jones[2] whose results with magnesium-lithium-cerium alloys, for example, do not show much promise of a useful precipitation hardening effect.

REFERENCES

[1] *U.S. Bureau of Mines, Report* 5250, July, 1956.
[2] *Journal of the Institute of Metals*, June 1956, page 364.

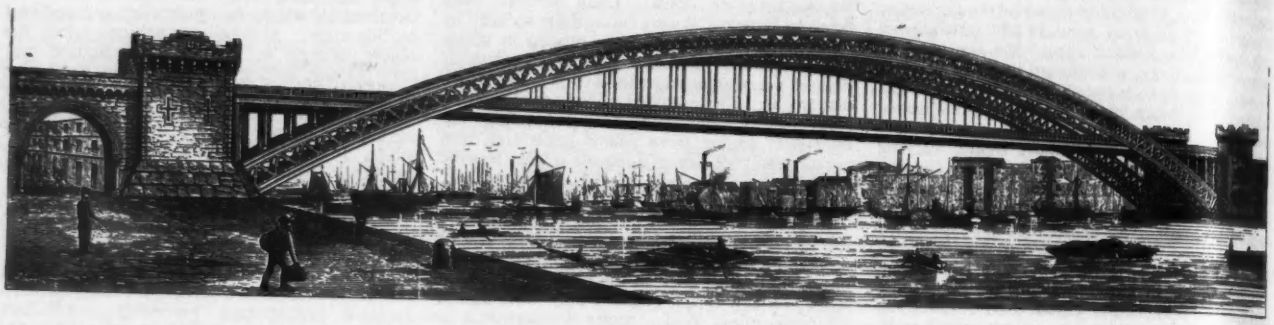
Wrought Titanium

A BOOKLET with the above title has been issued by I.C.I., Ltd., the pioneers of the commercial production of titanium in this country. Over a year ago, plant capable of extracting the raw metal at a rate of 1500 tons per annum came into operation. Progress has since been made in the technique of extraction and of working the metal, and a new rod-rolling plant of advanced design is being installed for the production of rolled rod and certain simple sections. The second edition of this booklet, issued in August 1956, gives an account of recent developments and contains much new information about the metal and its most promising alloys. At present I.C.I. supplies commercially pure titanium as billets and slabs, rolled plate and sheet, rolled or forged bar, drawn rod, wire and seamless tubes. Certain titanium alloys are also available in most of these forms.

The alloys available in the widest range of product are those containing aluminium and manganese, either 4 per cent of each or 2 per cent of each, their minimum tensile strengths at room temperature being 62 tons and 40 tons per square inch respectively. For these alloys details are given of mechanical properties including tensile properties at temperatures up to 600 deg. Cent., fatigue strength, notch sensitivity, and stress/rupture and creep properties at room temperature and at 350 deg. Cent. Another high tensile alloy, already supplied in billet or bar form but shortly to be available as plate and sheet, contains 6 per cent of aluminium and 4 per cent of vanadium. It has a tensile strength of 60 to 70 tons per square inch and maintains its strength well at moderately high temperatures.

The 5 per cent aluminium-2½ per cent tin alloy is available in billet or bar form, as rolled rod and as sheet. It is a medium-strength alloy (50 tons per square inch) with the additional advantages of good weldability and creep resistance at temperatures between 300 deg. and 400 deg. Cent. A more highly alloyed product, containing 13 per cent of tin and 2¾ per cent of aluminium, has been developed as a high-temperature creep-resistant alloy to meet certain requirements in aircraft engine construction, and shows a useful combination of properties at temperatures as high as 500 deg. Cent. Short-time tensile and creep properties between room temperature and 400 deg. or 500 deg. Cent. are recorded. Optimum creep strength has so far been obtained with heat-treated material.

ENGRAVINGS OF 1878

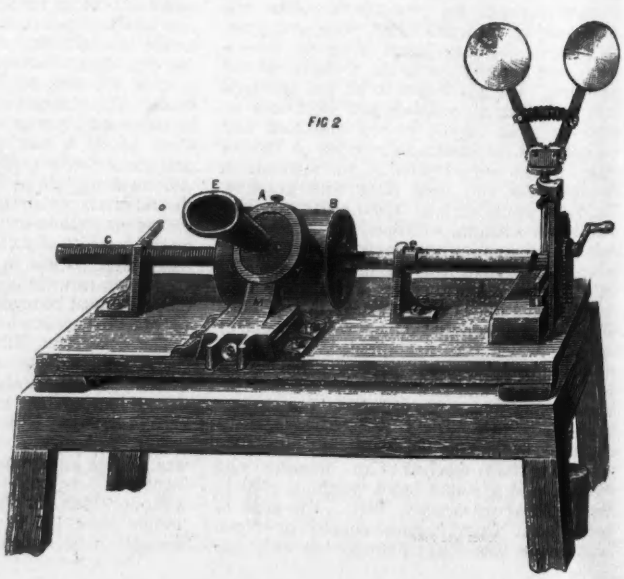


THE OBELISK: LOOKING EAST

In our issue of March 29, 1878, we printed the text of a report on a "proposed" Tower Bridge which was submitted by Sir Joseph Bazalgette to the Metropolitan Board of Works. The bridge, it was stated, was needed "to meet the pressing requirements of the public," but the report put forward the suggestion that "an opening bridge would be bad for the navigation and bad for the street traffic." A high-level bridge was therefore considered, which, the report said, "could be formed in three spans, with two piers placed in the river in the line of the present tiers of shipping, so as to give a clear width of navigable waterway, in the centre of the river, of 444ft, and two side openings of 184ft each, or the river could be crossed in one span of 850ft." Sir Joseph endorsed the recommendation for a single span, as shown in the above engraving. This design was for "a braced arch bridge, crossing the river by one span of 850ft, having a rise equal to one-eighth of its span, the roadway passing through the arch and being partly above and partly below its soffit."

In our issue of February 1, 1878, there appears an article dealing with the "merits and demerits of the several sites proposed as the permanent position for the Egyptian obelisk called Cleopatra's Needle." This article says that "after divers dangers and escapes the obelisk has arrived from Ferrol, and within the last month has found temporary safety at least in the East India docks." The site which was at that time being advocated for the final situation of Cleopatra's Needle was in St. James's Park, "at the end of one of the arms of the ornamental water, between the water and the parade, and opposite the archway through the Horse Guards." This engraving (left) gives an impression of the obelisk on that proposed site.

The phonograph, illustrated by the engraving below, is referred to in our issue of June 21, 1878, as a "beautiful apparatus" to which Mr. Edison had recently made a number of improvements. One of these improvements was "a clockwork action, with an excellent regulator." The mouthpiece (marked T) allowed "two voices to speak, or a duet to be sung, and thus two series of indentations to be made and reproduced at one and the same time."



Carbonisation and Chemical Plant at Wingerworth

No. I

The Avenue carbonisation and chemical plant at Wingerworth, near Chesterfield, is designed for the carbonisation of some 750,000 tons of coal annually and the production of 500,000 tons of coke, and 5000 million cubic feet of gas. Its processing plant will have an annual production of about 6,000,000 gallons of crude benzole, 13,500,000 tons of crude tar, 18,000 tons of sulphuric acid, and up to 12,000 tons of sulphate of ammonia.

LAST Tuesday the Minister of Fuel and Power, Mr. Aubrey Jones, officially opened the new Avenue carbonisation and chemical plant of the National Coal Board at Wingerworth, near Chesterfield. This plant, which has cost some £10,000,000, is stated to be the most completely integrated plant of its kind in the country. When in full production it will carbonise 2175 tons of coal a day to produce 1400 tons of coke and 27,000,000 cubic feet of gas. The associated chemical plant has been built to handle the by-products of both this and the other coke ovens in the East Midlands Division of the Board, and is capable of dealing with the by-products from a total of 4500 tons of coal a day. Its output includes sulphuric acid, sulphate of ammonia, benzole, pure toluene, pure xylene, pitch, pitch creosote fuel, high-grade naphthalene, carbolic and cresylic acids, pyridine and anthracene. Every section of the plant has been so designed that further buildings and equipment can be installed to double the existing capacity without interruption of production or need for changes in layout. At present coke is being produced for the domestic and industrial markets, but, if necessary, at any time the plant could be rapidly changed over for the manufacture of metallurgical coke.

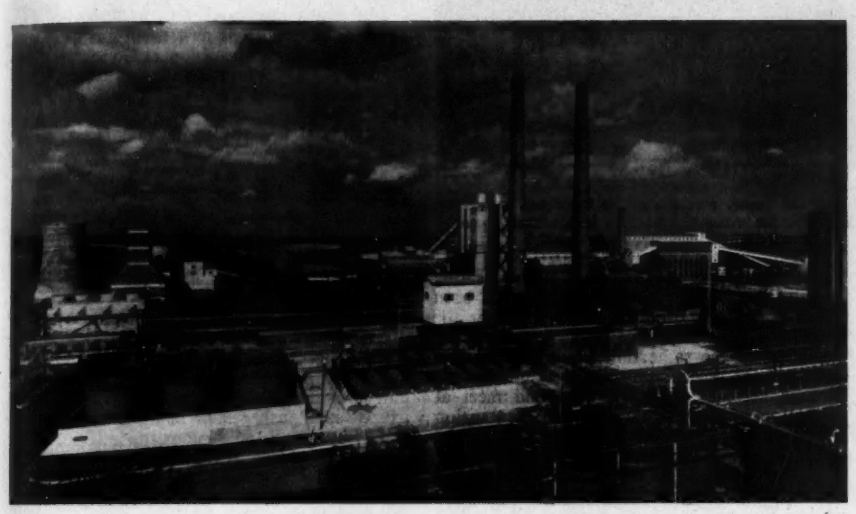
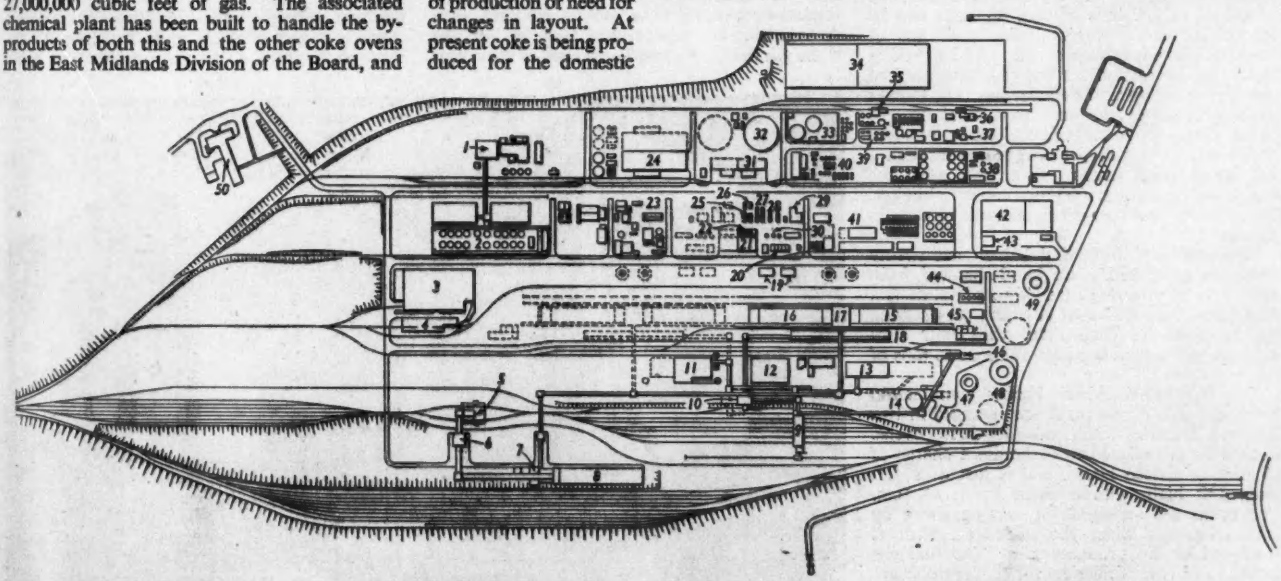


Fig. 1—The Avenue carbonisation and chemical plant from the north-west

The general layout of the plant is shown in the photograph and plan we reproduce on this page. It covers a site of 188 acres, down the length of which three main roads have been laid between the major plant lines with link roads at the ends and subsidiary branch roads to the plant buildings. A system of rail tracks, 13 miles long, serves the plant and, as can be seen from the plan, the main wagon sidings with access to the British Railways lines are situated along one side of the site. The site had a general steady fall from the west to east and the plant has been laid out on three main terraces. Its preparation entailed a maximum depth of cut of 30ft and a maximum depth of fill of about 25ft at the area on which the marshalling sidings have been built. The levels were so chosen that generally all the main structures are sited on excavated areas and the sidings on filled areas.

The main contractor for the plant was the Woodall-Duckham Construction Company, Ltd., which has been responsible for the work involved in site preparation, railways and roads, the coal-handling, crushing and blending plants, the coke oven batteries and machines, the coke-handling and screening plant, primary by-product recovery plant, benzole extraction and distillation plants, gasholders and gas boosting equipment, sulphate of ammonia plant, the producer gas plant, electrical power generation and power distribution equipment, and the water cooling and recirculation systems.

Coal is delivered by rail to the plant from a number of local collieries and consists mainly of mines ¼in washed slack of the 502, 602 and 702 classes. From the incoming sidings the coal wagons gravitate to either of two Mitchell combined automatically clamped side-discharge tippler hoists, designed to handle wagons up to 20 tons net capacity. The fall of the site was insufficient to permit a complete gravity flow of wagons through the plant, so the tipplers have been designed to receive the wagons on one level and release them at a level some 12ft higher on the other side after emptying. Incoming wagons are weighed before hoisting and again after their contents have been discharged into the overhead receiving hoppers. After release from the tippler the wagons gravitate to coke loading sidings, whence they are taken to marshalling sidings and coupled up into trains ready for their despatch on to the main railway lines.



1—Sulphuric acid plant.
2—Gas purification plant.
3—Maintenance workshops and stores.
4—Locomotive shed and garages.
5—Coal wagon hoist tippler.
6—Coal pre-crusher house.
7—Final coal crusher house.
8—Coal blending bunkers.
9—Secondary coke screening station.
10—Primary coke screening station.
11—Boiler plant.
12—Power station.
13—Producer gas plant.
14—Producer gas holder.
15—North battery of fifty-three coke ovens.
16—South battery of fifty-three coke ovens.
17—Ovens coal bunker.
18—Coke wharf.
19—Liquor decantation tanks.
20—Primary coolers.
21—Exhauster house.
22—Electro-detarrers.
23—Effluent plant.
24—Sulphate plant.
25—Primary naphthalene washers.
26—Secondary coolers.
27—Ammonia washers.
28—Secondary naphthalene washers.
29—Wash oil regeneration plant.
30—Benzole scrubbers.
31—Booster house.
32—Gas holder.
33—Tar bases plant.
34—Pitch bays.
35—Causticising plant.
36—Hard pitch plant.
37—Tar distillation plant.
38—Mixing plant.
39—Tar acid plant.
40—Naphthalene and anthracene plant.
41—Benzole rectification plant.
42—Water reservoirs.
43—Water treatment plant.
44—Secondary water cooler.
45—Coke quenching station.
46—Land-sale coke bunker and loading platform.
47—Water cooling tower (producer plant).
48—Water cooling tower (power station).
49—Water cooling tower (primary).
50—Divisional carbonisation headquarters.

Fig. 2—Layout of plant at the Avenue works

Fig. 3—Pusher side of north battery of the coke ovens with the pusher machine at the lower end of the row of ovens. The 4000-ton, 150ft high coal storage bunker for the ovens can be seen in the background

Each of the two overhead receiving hoppers has a capacity of 40 tons and through a double-acting reciprocating tray feeder in its base feeds the coal into a system of belt conveyors capable of handling 200 tons of coal an hour. The coal is screened and crushed and then elevated by belt conveyors to a transfer station at the top of the blending bunker installation.

The blending and storage bunker plant consists of eighteen reinforced concrete bunkers, each 110ft high and 30ft diameter, arranged in two rows with a head house extending the full length. It has a total storage capacity of 20,000 tons of coal. Conveyors running the length of the head house receive the coal from the transfer station and are fitted with travelling trippers which can be positioned to deposit the coal in any selected bunker. A hoppered outlet at the bottom of each bunker is fitted with a vibrating feeder, by which up to 120 tons of coal an hour can be fed on to belt conveyors below each line of bunkers. By adjustment of the vibrating feeders along the line of bunkers any required blend of coal can be fed on to the conveyors. The bunker conveyors deliver the coal to a final crusher house where it is reduced by swing hammer pulverisers so that 80 per cent passes through a ¼in square mesh screen. From this plant the coal is delivered to a 4000 tons capacity bunker, which serves the coke ovens and can be seen in Fig. 3.

This 150ft high oven coal bunker has twenty discharge gates which are hand-operated from the oven coal charging cars. Two portal design, electrically propelled coal charging cars serving the batteries are each fitted with four steel hoppers with a total capacity of about 16 tons of coal.

The Woodall-Duckham Becker combination underjet ovens of the plant are arranged in two separate batteries each of fifty-three ovens. Each oven is designed to carbonise a charge of 15 tons in sixteen hours, and is just over 41ft long, 13ft high, with a mean width of 16in. The ovens are arranged for heating either by coke oven gas when the underjet system is employed or by producer gas. The fuel gas piping and the underjet firing controls are located in a basement below the battery structure which is supported on reinforced concrete beams and columns.

The heating system consists of a series of vertical flues on each side of each oven and connected by cross-over flues over the top of alternate ovens. Beneath each series of vertical flues and connected to them there are two regenerators, each regenerator being divided by a central wall into two sections of half oven length.

When producer gas is used as the heating medium the regenerators serve to preheat both the producer gas and the air which enter the bottom of their respective regenerators at both sides and at the same time. After being preheated in the regenerators, the gas and air pass through specially designed ports and meet at the bottom of the vertical flues where combustion begins. The contour of the flues from the regenerators, up which the preheated air and producer gas travel, is such that burning gas is distributed throughout the length of each vertical flue and combustion takes place along the entire length of an oven wall simultaneously.

The products of combustion are collected from each group of vertical flues and carried over the top of the oven by eight crossover flues. From these crossover flues the waste gases are distributed into and pass down the vertical flues on the other side of the oven, then through the two regenerators and on into the waste gas flues. Automatic reversal of the valves is effected at thirty-minute intervals, to direct the producer gas and the air up through the regenerators through which the waste gas previously passed.

When coke oven gas is used as the heating medium the underjet system is employed and half the regenerators (alternate groups of four in the length of the battery) are used to preheat the air. The coke oven gas is fed from the fuel gas main through connections carrying the reversing and isolating valves to alternate pairs of cross header pipes in the basement beneath the battery structure. From the cross headers, of which there is one beneath each pair of regenerators, pipe connections lead the gas to the vertical ducts in the wall between the two regenerators. The gas passes up through ducts to the base of the vertical heating flues where it meets the preheated air and combustion commences. From the point of combustion onwards, the flow of burning gas and waste gas is similar to that for producer gas with the exception that the regenerators preheat the air only.

The ovens are fitted with a design of self-sealing door which is new to this country and was developed by the Koppers Company of the United States. With these doors a gas-tight seal is obtained by the contact of a knife edge on a special steel sealing ring with the faced door jamb, and an effective contact is ensured by the use of self-adjusting, spring-loaded, plungers. The door hangs from a self-centring shelf at the top of the door jamb, and is held in position by screw-operated door latches operated by oven machines.

Two pusher machines for discharging the coke from the ovens were made to the designs of the Koppers Company by James Buchanan and Sons, Ltd., and one can be seen in Fig. 3. Each of these machines is equipped to remove and replace the doors on the pusher side, push the charge of incandescent coke out of the oven and level the charge of coal in an oven. The welded steel pusher rams of these machines are driven by racks and pinions, their leveller bars are rope driven and they are fitted with rack and pinion-driven door extractor beams having worm-driven cast steel arms which lift and lower the oven doors. The door extractor equipment has a planetary-geared door latch tightening gear which is fully compensated to allow for any inaccuracy in positioning. Separate motors are provided on the machine for each of the six operations—travelling, door latching, door lifting, door extraction, coke pushing and coal levelling. There is a decarbonising device on the machine which enables air to be blown to the oven roof from a nozzle on the ram head.

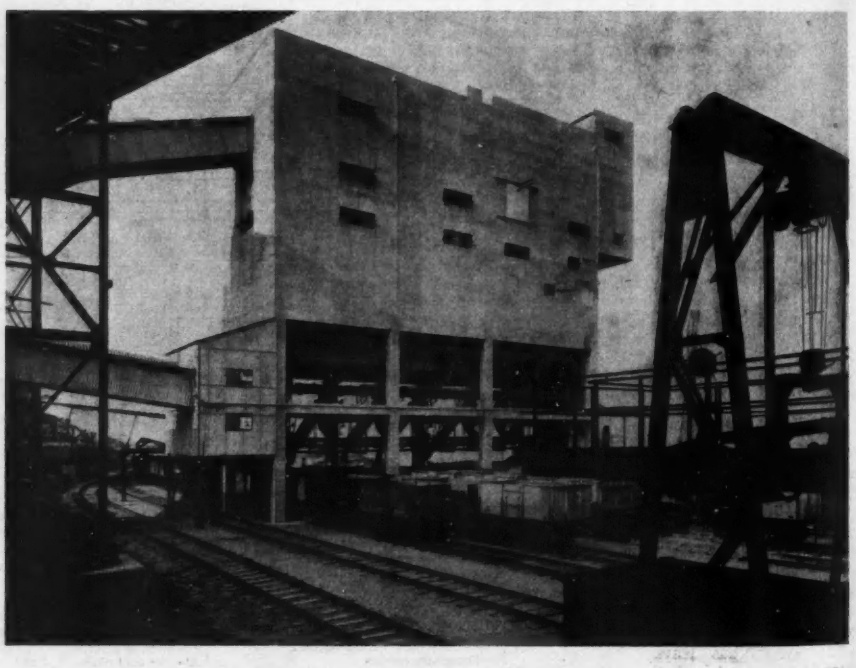


Fig. 4—Secondary coke screening station built over the loading sidings for the rail wagons

The pusher machines discharge 11 tons of coke in thirty seconds into one of two coke quenching cars on the opposite sides of the ovens. These cars have compressed air operated side-discharge doors and are hauled by electric locomotives between the ovens and the quenching station at one end of the batteries. The coke discharge sides of the ovens are served by two door extracting machines fitted with racking design trailing coke guides, and the door lifting and extracting and tightening gear of these machines is similar to that on the pusher machines. A door servicing station at one end of the coke oven battery is equipped with special manipulating and servicing equipment for the doors which, under the maintenance programme, are serviced in succession along the length of the battery, one door being changed each shift.

After quenching, the coke is discharged on to an inclined cooling wharf parallel to the coke ovens, and it is then taken by belt conveyors through a system of crushers and screens. Coke at plus 2½in is first removed and delivered by boom loaders to rail wagons and the remainder is delivered into a secondary screening station built over the rail wagon sidings. This station (Fig. 4) has two main operating floors accommodating screens above the storage hoppers.

Fig. 5—Benzole scrubbers, secondary naphthalene washers and ammonia washers

The hoppers have a combined storage capacity of 500 tons of the six following gradings: 150 tons each of 2½in to 1½in and 1½in to ⅞in; 100 tons of ⅞in to ⅜in; 50 tons of ⅜in to ⅛in; and 25 tons each of ⅛in to $\frac{1}{16}$in and $\frac{1}{16}$in to 0. Each compartment, with the exception of that containing breeze, is provided with outlets and chutes delivering to rail wagons or, alternatively, to conveyors serving the producer plant and boiler plant or to a land-sale bunker. Each of the outlets used for delivering to rail wagons is fitted with a debreezing screen and, with the exception of that for the smallest size of coke, with a boom loader to lower the coke into the wagons.

To provide the fuel for the gas producers and the boilers, breeze and all sizes of coke with the exception of the largest size, can be fed on to a belt conveyor from a second line of outlets and chutes in the storage hoppers. This conveyor delivers at a transfer station where a bifurcated chute feeds the coke or breeze on to one of two conveyor systems. One conveyor system delivers to the coke storage hoppers above the gas producers and the other takes the breeze to storage hoppers in the boiler plant.

The crude gas leaves the ovens through ascension pipes at both the pusher and the coke sides and passes into the gas collecting mains at each side connected by a bridge pipe. To control the oven top temperatures each bridge pipe is fitted with two fans, which provide forced recirculation of the raw gas in alternate directions through the collecting mains and ovens. From the centre of each bridge pipe there is an offtake main, connected to a suction main which terminates at a downcomer before the primary coolers.

Primary By-product Plant

The primary by-product plant is equipped for the cooling and washing of the gas for the recovery of tar and ammonia liquor, the removal of naphthalene and the dilution and boosting of the purified gas available for distribution. Gas from the downcomers passes in two separate streams to the primary coolers, exhausters and tar extractors.

Five Whessoe multi-pass vertical water-tube primary coolers are arranged to work in parallel, with two coolers for each gas stream and the fifth serving as a common standby. The coolers each have six passes and a water cooling surface of 16,500 square feet. Condensate from the coolers is collected separately in two fractions, the condensate from the hot ends being returned via a hot condensate sump to the liquor flushing and separating tank, and that from the cold ends to a cold condensate sump from which the cold liquor gravitates to a strong ammonia liquor sump and the tar to a hot condensate sump.

From the primary coolers the gas is passed by B.T.H. axial-inlet radial flow exhausters to electro-detarrers. One exhauster is used for each gas stream, and there is a third serving as a common standby. The four vertical tube, suspended wire electrode, Whessoe W-D electro-detarrers are each 8ft in diameter and normally two are in operation on each gas stream. From these detarrers the gas passes through four primary naphthalene washers and, after recooling in two secondary condensers, to the ammonia washers and secondary naphthalene washers (Fig. 5).

After the removal of the tar, ammonia liquor and benzole the gas is automatically diluted with producer gas to obtain the required calorific value, before it passes into a dry gas purification plant for the removal of hydrogen sulphide. The required volume of gas for firing the coke ovens is then directed into the oven gas main and the remainder delivered to a 500,000 cubic foot capacity two-lift, spirally-guided gasholder, whence it is metered and boosted for delivery into the mains of the East Midlands Area Gas Board.

An ammonia liquor circulating system in the gas collecting system of the ovens is supplied with flushing liquor by two pumps, which transfer the liquor to the ammonia washers. Four liquor floating head coolers are provided to cool the liquor bled off from the flushing system before it is used in these ammonia washers and/or for cooling the condensate from the benzole plant separators. Two liquor flushing and separating tanks of mechanically operated scraper design have a decanting capacity of 45,000 gallons. For each separating tank there are two 3500-gallon receiving tanks, into which the tar overflows and one 10,000-gallon receiving tank for the decanted liquor.

A three-compartment reinforced concrete condensate drain pit receives the liquor from the ammonia washers and the hot and cold condensate from the primary coolers and by-product plant apparatus. Its strong liquor compartment has a capacity of 6000 gallons and the hot and cold condensate compartments are each of 4000 gallons capacity.

An oil regeneration plant treats the mixed oil from the naphthalene washers and delivers a naphthalene-xylene oil fraction to the tar receiving tanks and returns the stripped oil to the naphthalene washers.

Gas Purification Plant

The tower design gas purification plant, supplied by Newton, Chambers and Co., Ltd., comprises two sets operating in parallel, each set being capable of purifying half the total throughput of 26,000,000 cubic feet of gas a day. The process is based upon the normal reaction between hydrogen sulphide and a contact mixture of hydrated oxide of iron.

Each of the two sets comprises six welded steel working towers, 22ft 4in diameter by 65ft high. The contact material is held in baskets or containers, each of which holds about 25 tons of oxide in two layers supported on wood grids, there being fifteen such containers to each tower. The gas to be purified enters the base of each tower, passes up an internal central duct, through the layers of oxide and leaves the tower through the outlet connection located about halfway up the outer shell.

Each of the two sets of towers is provided with a stocking tower in which containers of spent oxide are placed as they are taken from the working towers, and also with a stocking frame, in which containers of fresh oxide are stored prior to their being placed in the working towers. Spent containers are removed from the towers and replaced by containers of fresh oxide from the stocking frame, by a 50-ton Goliath travelling crane. A specially designed lifting frame slung from the crane has an automatic mechanism for locking the hooks in the required position when lifting or lowering containers, or when withdrawing the lifting frame from the towers.

A handling system installed for the spent material enables the oxide to be delivered to the sulphuric acid plant or to a stocking area. Partly spent material for re-use is reduced in size in a granulator and returned to a hopper for mixture with the regenerated oxide from the acid plant or new oxide when recharging the containers. Provision is made for purging each tower with inert gas.

The equipment in the gas booster house includes four gas compressors manufactured by G. Waller and Co., Ltd., each of which is capable of compressing 6,000,000 cubic feet of gas per day and delivering it at a pressure not exceeding 25 lb per square inch. These boosters are of two-crank, compound, double-acting, vertical construction, two being steam driven and two motor driven. The motors for the electrically driven constant speed sets are located in a separate room of the booster house and the drive is by V-rope pulleys on a shaft extending through a wall box to the boosters in the main room of the building. Two positive displacement "Connersville" meters in this house each have a nominal capacity of 10,800,000 cubic feet of gas per day.

In a separate exhauster house the exhausters are supported on an elevated platform beneath which are the gas mains. Also accommodated in this house on the ground floor are the pumps used for liquor flushing and tar transfer, and the loading and condensate pumps.

(To be continued)

Aldenham Bus Repair and Overhaul Works

A new bus repair and overhaul works opened by London Transport at Aldenham is organised and equipped for the overhaul of fifty-six vehicles a week. This works will, allowing for the normal rate of replacement, provide for a fleet of 11,000 *vehicles being overhauled every three-and-a-half years.*

FOR more than thirty years the motor buses of the former London General Omnibus Company and its successors were overhauled at the Chiswick works, which were originally laid out to cover the overhaul work required in maintaining a fleet of some 4000 open-topped vehicles. With modernisation and extensions, the capacity at Chiswick had been increased by 1939 to handle the work for the 6000 covered-topped vehicles then serving London. Since the late war, however, the task of maintaining an overhaul programme with the rapidly increasing numbers of vehicles in service has been getting beyond the capacity of the Chiswick works. In 1950 the introduction of the R.T. type bus by London Transport to form the backbone of its fleet enabled the interval between overhauls to be lengthened to an average of three and a half years, and although this gave some relief to the facilities then available, its effect was more than counterbalanced by the increased size of the fleet in service. This fleet, it was estimated, would reach 10,000 vehicles by 1959. It was, therefore, decided to establish a new depot at Aldenham, on the Watford By-pass, and reorganise completely the system of overhauling buses. This reorganisation has now come into effect, and only the mechanical and electrical parts of a bus, such as the engine, gearbox, axles and batteries, are overhauled and reconditioned at the Chiswick works. The new Aldenham depot is primarily responsible for the dismantling, overhauling, rebuilding and repainting of complete vehicles; the fitting of reconditioned units from Chiswick in place of those removed, and the making and reconditioning of body parts.

The new factory has been erected on a fifty-four-acre site and its main works building is some 1500ft long by 500ft wide, with subsidiary offices, canteens and stores in adjacent, smaller buildings. The works has been equipped to overhaul fifty-six buses a week which, allowing for the normal rate of replacement, provides for a fleet of 11,000 vehicles being overhauled every three and a half years. In laying out and equipping the factory the standardised design of the R.T. type buses and the complete interchangeability of their components has been used to good advantage. Under the system used components are overhauled and, in rebuilding, no attempt is made to reassemble the units back into their original vehicles. In the main factory the working floor has been arranged along lines in the form of a 1000 yard long "U," with vehicles for overhaul arriving at the end of one leg and, after passing through various stages of stripping, repairing and assembly down the shop, passing up again through the paint and finishing stations to the top of the other leg. The area in the centre of the production lines contains manufacturing lines and stores which feed out into appropriate stations in the overhaul sections.

Throughout the greater part of the main factory a clear working height of 20ft is provided, which is adequate for dealing with ordinary work on road vehicles having an overall height of 15ft. Towards one corner, however, there is a "high-bay," about 850ft long by 130ft wide, which provides a clear headroom, beneath the roof structure, of 50ft. The purpose of this high area is to enable a bus body to be lifted by overhead travelling crane, and carried over a row of other bodies, as shown in Fig. 1. It provides an economical use of floor space in this area by permitting bodies to be moved through various stages of repair in the minimum time and with the least inconvenience to other work in progress and likelihood of damage.

Buses for overhaul are drawn in turn from a large parking area and passed into an inspection area, where the repair work required is marked on the body and the necessary process sheets are made out. The bus is then placed over one of four dismounting pits at the end of the "high bay" section of the working lines. At these pits the connections between the chassis and body are disconnected and the body lifted by the overhead cranes serving the length of the shop. The special slings used for this purpose are fitted with adaptors by which they can be set to lift any type of body in use on the London Transport system. The body is transferred to a cleaning cubicle at the head of the repair shop and the chassis is removed to an adjacent overhaul section. In the cleaning cubicle the body is placed on a special cradle, known as an inverter, on which it can be turned sideways up to 90 deg. to give free access for cleaning of the underside by means of a high-pressure jet of hot water.

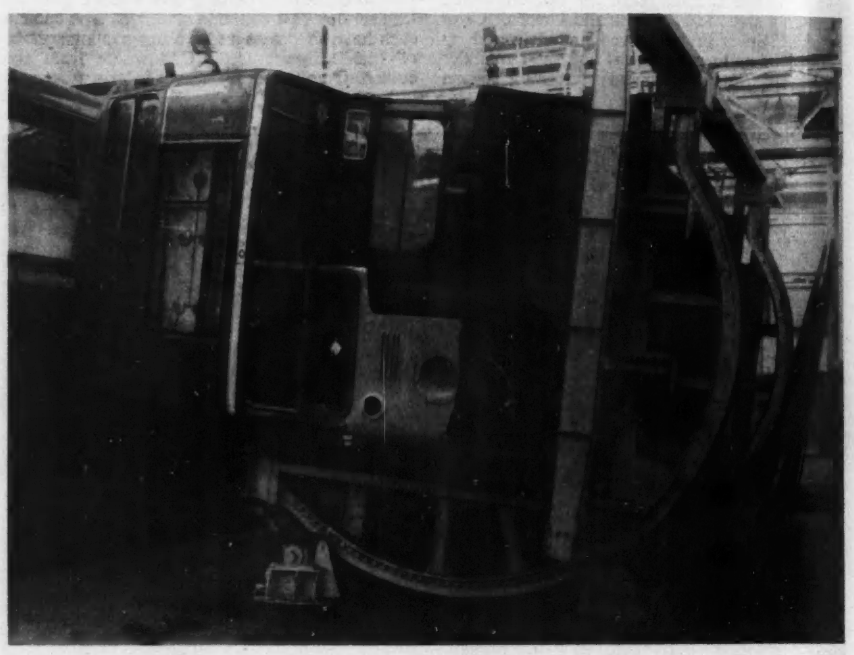


Fig. 2—Inverter carrying a bus body and turned through 90 deg. for work on the underside

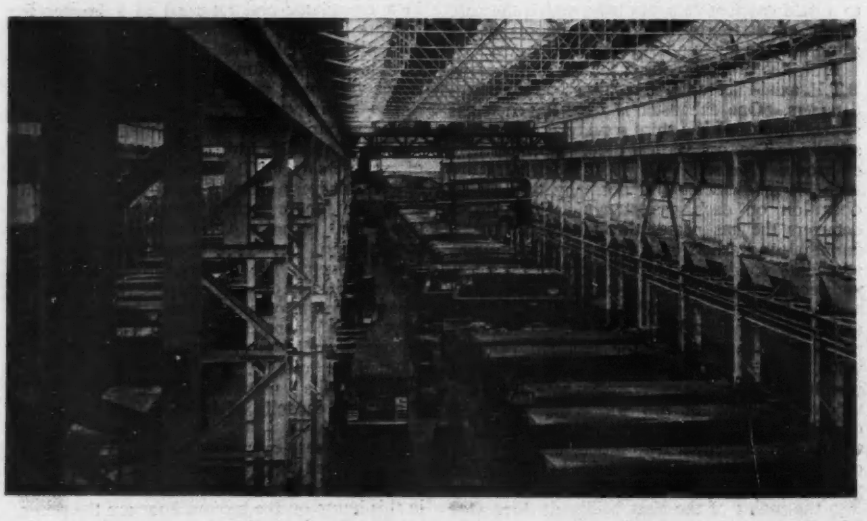


Fig. 1—"High-bay" in which bus bodies are overhauled and repaired in "standings." The chassis overhaul shop is situated on the right of this body section

One of these inverters, a number of which are used in the works, can be seen in the illustration, Fig. 2. The machine consists of a cradle with pads on which the body support fittings register and having extension arms on one side against which the body rests when turned about its horizontal axis. The cradle arms are each carried on two pairs of rollers and incorporate roller pins gearing with pinions driven by an 8 h.p. motor. Through this cradle drive an inverter can turn a body over from the vertical to the horizontal position in twenty seconds.

After cleaning, the body is transferred to an adjoining inverter where its underside is inspected and any necessary underfloor repairs are carried out. The body is then transferred to one of forty-nine standings arranged on each side of a main gangway down the length of the high bay illustrated in Fig. 1. In these standings (Fig. 3) bodies are supported at four points on stilts for the necessary repairs to its structure and

covering. The body support stilts are adjustable for height by means of distance pieces to give two working positions—low and high—in addition the stilts act as jigs to prevent distortion of the body during repairs affecting chassis location points. Work is carried out from the floor and from a fixed height gantry which surrounds each standing, and is provided with adjustable counterbalanced lifting platforms at the sides and ends of the vehicle.

Work is carried out by a team of tradesmen allocated to each standing and fitters and electricians working from a small central area serve a number of standings. Each group of ten standings has its own set of stores and spares racks which are kept supplied from a central stores. This system of storing a supply of components at the standings from which the tradesmen help themselves obviates the use of requisition forms and saves much time which would otherwise be lost in travelling to and waiting at central stores.

Fig. 3—Bus bodies in repair standings. A body carried in special slings from an overhead crane is being moved to a standing from the dismantling bay

When the repair and overhaul work required on a body is completed it is taken to the end of the line of standings and set on an inverter. Here the body is tilted and the underside of the floor sprayed with preservative paint before it is moved away to an adjacent area.

The chassis overhaul shop (Fig. 4), as already mentioned, adjoins and is parallel to one side of the body repair lines. In this chassis shop two sets of conveyors run down one side of the central gangway, on the other side of which are repairing and stocking areas. An incoming chassis from the dismounting section is placed on a trolley coupled to a 375ft long moving rope conveyor driven continuously at a speed between 7in and 15in a minute. On this trolley the chassis is first carried through a washing tunnel where water at about 35 lb per square inch pressure and heated to 150 deg. Fah. is projected on it from all angles by a series of nozzles. This operation removes most of the dirt and is followed by washing with hand-operated high-pressure hot-water jets to remove any remaining dirt from inaccessible places. After passing through a hot air drying chamber the chassis is drawn on the conveyor through the stripping stations in the main shop.

As the chassis moves along the stripping line complete units, such as the front and rear axles and steering gear, are removed; unless major repairs are necessary on the frame in the region of the engine and gearbox they are left on, as these two units are usually serviced or changed at depots under the normal maintenance programme. The front and rear axles have their springs and road wheels removed and, together with the steering gears, are packed in special stillages for transport to Chiswick for overhaul. At the final stage of the stripping conveyor the chassis frame is inspected with a gauging fixture and then passed to a repair section at the other side of the shop for reconditioning. Springs, wheels and other parts are reconditioned in other sections of the shop.

A second moving platform conveyor in line with the stripping conveyor is used for reassembling chassis by building them up with reconditioned units drawn from a central stores on to overhauled frames from the repair section. This assembly conveyor consists of a series of concrete slabs 10ft long by 3ft wide, which are set lengthways across and moved along a roller track. At the end of each forward movement of the conveyor line the slab at the end moves vertically downwards and is turned by hydraulic rams through 90 deg. into a channel running below and between the main roller tracks. In this channel system the slabs are returned at a higher speed to the conveyor head, where they are turned and raised into the forward line.

As the chassis moves along the assembly line the various units are fitted and the engine, gearbox and back axle filled with oil. At the end of the line a special frame gauge is lowered by a pneumatic hoist on to the completed chassis. This gauge is equipped with plugs and reference edges by which all the parts of a chassis which make contact with the standard bus body are checked. After final detailed inspection the chassis is then towed into a booth where it is sprayed all over with protective aluminium paint. This booth is fitted with a tilting frame on which the chassis can be tilted sideways up to 30 deg. from the horizontal each way to give access for painting the undersides.

At the end of the overhaul lines the bodies are mounted on the chassis and the buses, complete except for their internal fittings, are given a road test within the precincts of the works. Any necessary rectifications are then made to the vehicles before they are passed into a preparation shop, where they are washed and rubbed down ready for painting. The vehicles are here fitted with special standard masks over the windows and entrances, before being taken to the head of the painting line, where they are placed on a conveyor 680ft long.

This spray painting and varnishing line for the exterior of the vehicles includes three spray booths and two drying ovens, through which the conveyor runs and once each hour carries forwards the line of sixteen vehicles, spaced at 40ft intervals, a distance of 40ft. This interval and the spacing of the vehicles is set by the spacing of the booths and the time a vehicle requires for paint hardening and the completion of certain operations between the booths. Each booth has power-operated doors at the ends, and these doors are automatically opened and closed between conveyor movements.

Each booth takes one vehicle at a time and has power-operated platforms on each side with cross extensions at the front and rear. Operators standing on these platforms can raise or lower them as required to reach all parts of a bus with their spray guns. Air at a temperature of 75 deg, Fah. is fed into the booth from grilles along each side of the roof. This air extracted over water troughs below grilles in the floor, and in its downwards flow provides a protective curtain for the operators.

In the first booth the vehicle is sprayed with two colour coats, wet-on-wet, and on leaving this booth remains in the open shop for three moves of the conveyor. During this time the paint dries and, in addition to any touching up which is required, sign writing is carried out and the transfers are affixed for the vehicle user's name and the bonnet number. In the second booth a coat of varnish is applied and the vehicles then pass into a 120ft long drying oven maintained at a temperature of 130 deg. Fah. The length of this oven enables it to accommodate three vehicles, so that each bus remains in it for about three hours. After they leave this oven the vehicles cool down for two hours on the line and then pass into a second varnishing booth and oven similar to the first.

When they are removed from the painting conveyor the buses are set on a finishing line conveyor, after all the masking has been removed in a marshalling area where they are cleaned and the advertisements are attached. On this finishing conveyor final cleaning of the exterior is done and the interior fixtures, rails, seat cushions and other parts are fitted. The finished vehicle is then driven to a final inspection, testing and licensing section before being passed out for return to its depot.

As already mentioned, the main mechanical parts of a bus are dealt with at the Chiswick works, but all of the panels, body fittings, seats and other parts are overhauled and certain replacement parts are made in the central area between the overhaul and painting and finishing lines. These repaired parts and replacements are fed into stores adjoining the finishing conveyor line, and from these stores the parts are delivered to racks by the appropriate line stations. Supplementary sections feeding the finishing line include a bonderising and stove enamelling shop, a wood-working shop and a trimming shop for upholstery.

A large repair shop at one end of the factory is set aside for accident repair work in cases where the damage to a body is not sufficient to justify it being removed from the chassis.

Fig. 4—End of chassis reassembly line conveyor. The master reference jig for body mounting points can be seen on the completed chassis. The chassis frame and component repair sections are on the left

Twin-Engine Two-Stroke Track-Layer

AN impressive machine which proves to be remarkably straightforward in its construction is the Euclid T.C.-12 tractor. This is powered by a pair of two-stroke diesels with a power output of 194 h.p. each at 1800 r.p.m.—365 h.p. is the total power available to the transmission—and weighs 25 tons dry. As can be seen in Fig. 1, the two halves of the tractor are articulated, and since each engine drives one track, the two parts are almost completely independent.

The engines are General Motors 6–71 (six cylinders, each of 71 cubic inches) with three-lobe Roots blowers, poppet exhaust valves, and low-pressure common-rail fuel systems, with open injectors driven from the camshaft. The engines of this series can be built up to drive from either end and, thus, on both halves of the tractor the engine has the blower and other auxiliaries on the outside. Therefore, except for such items as transmission oil pump drives, the vehicle is in essentials symmetrical, and only one side need be described in detail.

The engine is mounted near the front of a long fabricated girder, immediately in front of the cowling, which stiffens the frame. In this application the high power-weight ratio of a blown two-stroke is not in itself valuable and the two-cycle engine is used because oil engines are an expensive form of ballast. Inside the flywheel is a spring cush hub, driving a stub-shaft running in two roller bearings in the flywheel housing. From here a long, universally jointed, drive shaft runs back under the fuel tank to the transmission.

Behind the second joint a pulley drives two belts running up to the front of the fan shaft. Cooling air is inducted through the grilles on the decking and forced by the fan through the radiator, the filler cap of which can be seen in Fig. 3. The coolant passes through the engine oil cooler, the water pump, the cylinder water jackets, back to the transmission oil cooler, and re-enters the radiator past a thermostat.

An Allison hydraulic torque converter is used, with a single turbine preceded by two stators that commence to free-wheel independently as the coupling condition is approached. For this application the three-stage Twin Disc torque converter, described in these columns on March 9, 1956, page 249, was also considered: this would, however, have had to be run with a higher final drive ratio to keep it out of the inefficient low-slip condition, and therefore the advantage of the greater stall torque would not have been realised. Behind the converter is an Allison "Torqmatic" transmission, consisting of two compound epicyclics controlled by five clutches: the two clutches on the first train give forward or reverse, and the three on the second train give three output speeds with torque-sustained changes. The transmission is mounted within the large final drive casing which acts as its oil tank and closes the rear end of the main frame. The output shaft drives, through spur reduction gears, a right-angle bevel drive, and on this shaft is the metallic-faced multiple disc brake, operated by foot pressure. Another drop-down train follows at the outer end of the casing.

The power is then delivered by a fully floating shaft through the hollow shaft on which the drive sprocket runs: the shaft is splined to the sun wheel of an epicyclic contained within the large hub visible in Fig. 2. The sprocket itself consists merely of a ring of teeth bolted to the circumference of this large drum, so that complicated stress fields are largely avoided. The centres of the three planets can be discerned on the face of the drum. The only moving joint to be sealed against dirt entering or oil leaking is of small diameter on the inner face of the sprocket: here there is a combined dirt and oil seal. The sprocket teeth engage with hardened steel bushings on the pins, also hardened, which unite the track links on each side of the wheel. These links are induction hardened on the inner face, upon which the tractor rolls, but otherwise left in a tough condition. The pins are pressed into the links, except for the master, which is a heavy drive fit. Each track plate, normally 26in wide, is secured to a pair of links by four hexagon bolts and nuts, the nuts being unable to turn on the links. Each plate has a 2¾in grouser. The total ground contact area is 6000 square inches, giving a mean ground pressure of just under 10 lb per square inch.

There are seven rollers under the track frame, of live-shaft pattern with double-row barrel-roller bearings in the frame. Both ends run in a common oil supply intended to last 1000 hours, and a small tube running from one end of the roller to the other prevents the oil collecting in the hollow body of the roller. Combined oil and dirt seals appear again at each end of the rollers. The two track support rollers run on overhung dead shafts. The idler is a cast steel spoked wheel, and slides on the frame on wearing plates. Automatic track tensioning is provided: a hydraulic ram drives the idler forward, and is pressurised by a nitrogen reservoir at 1000 lb per square inch: these two cylinders can be seen on top of the track frame in Fig. 2. This arrangement allows the idler to retract fully if a rock is drawn in between the track and the sprocket: the return of the idler is heavily damped, grease being the working medium.

The track frames carry, both inside and out, large ball-ended fittings for equipment mounting: in the illustrations those on the outside have been removed to reduce the width of the vehicle. The frame is carried from the main structure by two outriggers, visible in Fig. 1. On the rearmost can be seen a square cap: this gives access to a 7in diameter shaft which is clamped in the left-hand part of the tractor and about which the right-hand portion pivots freely: bushings are provided at both sides of the right-hand part, and a thrust washer at the outside. The travel of the tractor halves is limited by stops in between the engines to about 7½in each way at the front end, where there is a roller guide to protect the pivot shaft from excessive bending moments. At the opposite end of the hulls there are rubbing plates, which normally do not touch, as a safeguard against axial clearance developing.

Shared between the two sides is the hydraulic system. The tank holding hydraulic fluid is on the right-hand unit, and the pump is driven from the right-hand engine. The control valve is situated in front of the left-hand engine. The two rams are pivoted to the outer ends of shafts journalled in massive sleeves crossing in front of the engines. Flexible hoses accommodate movement of the two sides and of the ram bodies. In front of the tractor can be seen a frame to carry a 'dozer blade at any of five angles: despite the fact that the pick-up points on the track frames do not lie on the pivot shaft axis, it is fabricated in one piece. A buffer plate for pushing fast rubber-tyred scrapers when loading can be mounted on the ball pegs inside the track frames and carried by the rams. Tractor-powered scrapers can be towed and are operated by the power control winch, seen at the rear of the right-hand sub-unit in Fig. 2.

The operator rides the left-hand side. High up in front of him are the two governor setting levers, and near the bottom of their column are the single progressive transmission selector and the ram control lever. On the upper adjacent corners of the cowlings are the starter buttons, stop knobs and emergency stop pulls: outside them are indicators for coolant temperature, oil pressure and temperature, and, on the right-hand side, battery charge. At the left-hand side of each unit are the brake pedals and pedal locks. At the driver's left are the two forward and reverse selector levers: these, unlike all the other hand controls, are reactive, so that they

Fig. 1—The twin-power crawler in an attitude of maximum articulation. The frame in front of the tractor picks up on ball lugs bolted to the faces at the middle of the track frame; above that face on the nearer frame is seen the nitrogen cylinder for the track tensioner

Fig. 2—A scraper cable control unit is seen above the draught gear. To the left of the operator are the two forward-reverse selectors. At the rear of the engine access opening can be seen the upright ether container for cold starting

can be engaged progressively. The controls for a scraper extend across from the right-hand part. A single switch brings sealed beam lights into action, front and rear.

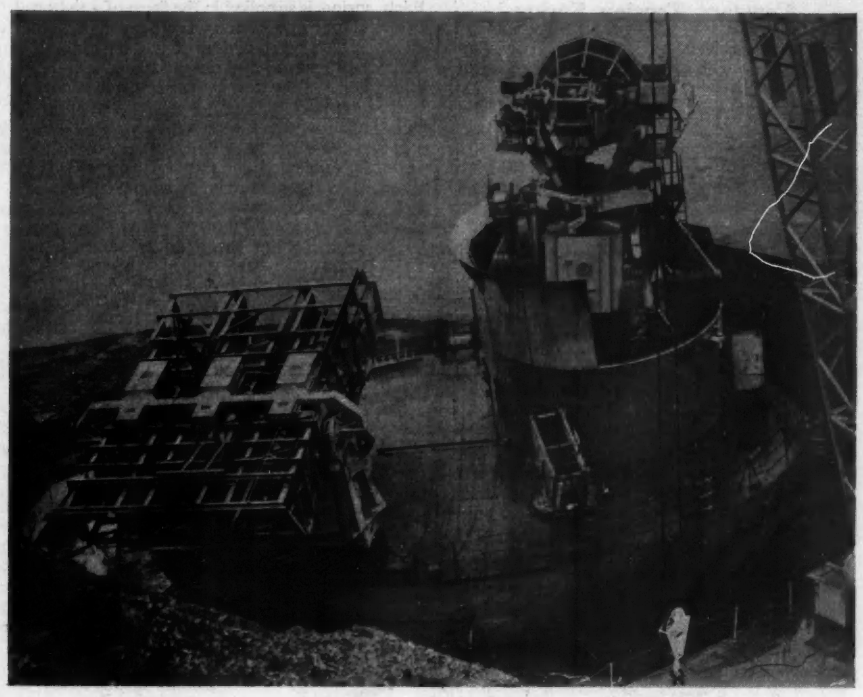
The tractor was introduced to us at the Hunsbury Works, Northampton, of John Blackwood Hodge and Co., Ltd., who is displaying it at the Public Works Exhibition, and from whom it will be available from January 1, 1957. On a cool, dry autumn morning the electric starters spun the engines very readily but for many seconds to start them : the hand

Fig. 3—Cooling air enters down the grilles, passes through the radiators—one filler can be seen—and leaves through the louvres in the foreground. In front of the driver's seat are the governor, transmission and hydraulic controls. The hydraulic oil filler cap shows on the right-hand engine cowling. The two intake air cleaners for each engine can be seen

priming ether systems were not used. The generator being on the right-hand unit, that engine is normally started first. When both banks of six two-cycle cylinders were running, the noise was noteworthy, reminiscent rather of an aero engine than of the familiar heavy earth-moving plant. Because of the great directional stability of crawler tracks, it is not necessary to synchronise the governor levers carefully : it was demonstrated to us that the unloaded vehicle could be manœuvred on one engine. If the governor controls are displaced greatly, the tractor performs a gentle turn, which can be tightened when the inner engine is declutched. Skid turns simply require the lever to be drawn further back into reverse. The bucket seat locates the driver, while a footrest is provided between the brake pedals, which are very wide apart.

The two air cleaners for each engine are reached, without any dismantling, under the cowlings in front of the driver. The oil reservoirs have long flexible dipsticks, attached to the filler caps for hydraulic and transmission oils, convenient outside the blower casing for the crankcase. The batteries are located in the side panniers at the rear. While on early versions the nose panels, for instance, were hinged for quick access, all detachable cowls are now secured by bolts.

The governed maximum speed of the twin-power crawler is 8·3 m.p.h. : at 4 m.p.h. it has a tractive effort of 10 tons, and even in top gear its maximum pull is nearly equal to its own weight. In second gear, at 2·5 m.p.h., the drawbar pull is 16 tons and in first 37 tons at 1 m.p.h. The width over the tracks is 11ft 4in; a 15ft 2in blade can be carried square, or an 18ft blade square or at an angle.



The Clausen rolling platform can be ballasted to simulate the motion of various sizes of warship : it can pitch 10 deg. and roll 20 deg. Missiles are crane loaded on to the cradle behind the radar tower

Missile Experiment

We visited last week the Royal Aircraft Establishment, Aberporth, a missile range. Firings are directed northward over Cardigan Bay, target aircraft, when required, flying from an aerodrome at Llanbedr. Just above sea level is located the Clausen rolling platform, a circular ship floating in a small basin which can be excited in roll and pitch by " urgers " on the dockside. Within, the shell closely resembles a warship, 60 cycle alternators being installed. On deck are mounted a radar antenna and triple rocket launcher ; when the float was moving the radar set appeared to be perfectly stabilised, while the launcher followed it in finite steps. From it an Armstrong Whitworth vehicle, intended to yield data for a ship-to-air missile, was fired. The instrumentation included a set of luminescent dials, recorded on a continuously moving film by illuminating them with a flash strobed from the time base.

Other firings witnessed were of an English Electric rocket-propelled test vehicle and a Bristol ramjet test vehicle. The latter had two ramjets, resembling the " Thor " described on page 203, August 10th, mounted well aft on a body about three times as large as the engine, and was accelerated off the launcher by eight solid motors. An actual missile was seen when a " Fireflash "-carrying Hawker " Hunter " made a run at about 500ft ; one missile was fired unguided, the other failed and was jettisoned by an explosive release.

The missile tracking system uses radar range-finding and obtains direction from lock-follow aerials. The projectile is also followed by kine-theodolites and Doppler techniques. Reflection methods are too limited in range for this application and, therefore, a transponder is carried on the vehicle ; four receivers are necessary to locate unambiguously a rolling missile. The resulting problem in solid geometry is interpreted by a " Deuce."

Information from vehicles is telemetered to earth, on a twenty-four-channel time-division-multiplex or a twenty-channel pulse-position method analogous to range-finding. Data recording is predominantly on film, with subsequent manual interpretation ; a technique of treating kine-theodolite pictures, in which the operator has only to position pointers and cards are punched to correspond, was demonstrated. Experiments have been made with transferring incoming information to magnetic tape instead of oscilloscopes, for automatic data reduction.

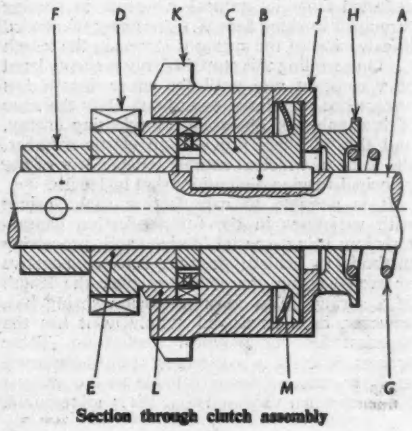
Break-Away Clutch

At the Tiltman Langley Laboratories at Redhill, Surrey, a positive clutch that can be disengaged under high torque has been developed. The operation of the clutch can be followed on the drawing : the shaft *A* drives by a freely sliding key *B* the driving hub *C*. Ratchet teeth on this hub engage corresponding teeth on the driven gear *D*, which runs on an " Oilite " bush *E* and is retained by collar *F*. The ratchet teeth are held in engagement by spring *G* abutting the sliding collar *H* and the flange *J*.

When it is required to withdraw the clutch, control wheel *K* is arrested by a brake or pawl. Continued movement of the driven gear moves the control wheel to the right by the action of cams *L* concentric with the ratchet teeth. The output gear continues to be driven until the spring cup washer *M* has been compressed sufficiently to draw the driving hub clear of the ratchet teeth : the hub will then come to rest against the inner face of the flange *J*.

The control wheel will now be resting on the cam tracks of the driven gear : provided the driven gear comes to rest within the extent of the cam dwell and does not move again, the clutch teeth remain apart. When wheel *K* is freed, friction causes it to rotate with *C*, and the ratchet teeth are driven together by spring *G*.

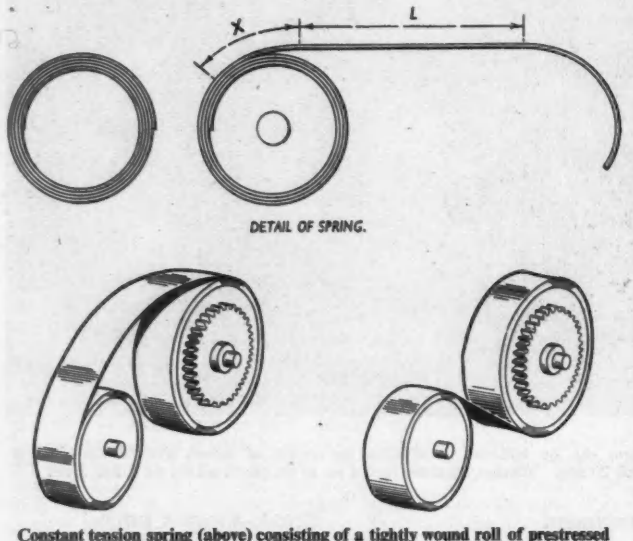
The capacity of the clutch is limited by the strength of the components, Units with a hub diameter of ¾in are used to run at 420 r.p.m. and transmit torques up to 60 lb-in.



Section through clutch assembly

Constant Tension Spring

We have received particulars of a constant-tension spring which is now being made in this country by Tensator, Ltd., Acton Lane, London, N.W.10, under licence from the Eastern Metals Research Corporation of the United States. These springs are made of specially formed strip with a slight uniform curvature across the width and which during manufacture is prestressed by a system of reverse bending and heat-treatment. The method of manufacture imparts a system of residual stresses across the material section. Springs thus made, it is claimed, exert a constant restraining force to resist uncoiling and when mounted on a freely rotating drum are capable of undergoing a very large degree of uncoiling with a negligible build-up in the restraining force. The full restraining force imparted at the free end of a spring is constant throughout extension to the predetermined limit, and is likewise maintained up to the completion of return from the extended position.



Constant tension spring (above) consisting of a tightly wound roll of prestressed strip material. Two forms of constant torque motors fitted with these springs are shown diagrammatically (below)

The maker points out that the particular properties of this form of spring suit it for application in counterbalancing devices, constant tensioning mechanisms, constant contact-pressure or load-feeding equipment, return gear for machine carriages or slides, long running re-reeling motor mechanisms, such as are fitted in cine-cameras, and in practically all applications where a long-deflection, elastic member exerting a restraining or returning force does not increase its load during extension or retraction.

The operation of this form of constant-tension extension spring is based upon the fact that the strip used is so stressed that it can be deflected from a small curvature to a completely straightened condition without permanent deformation. When the "Tensator" spring is extended, as shown diagrammatically above, each part of the straightened portion has been deflected from its natural curvature in passing through a working zone *X*. The energy expended in extension of the spring is stored in the length *L*. On recoiling this stored energy is surrendered at a constant rate until the entire length *L* is restored to its relaxed condition. Only the zone *X* is capable of absorbing or releasing energy, and this in effect provides an elastic member, the force of which is entirely independent of the principal varying dimension, that is, length.

It is possible to manufacture such springs with variations in the force-deflection characteristics, using special design and processing methods to achieve positive, zero or negative or even varying characteristics over the length of a spring. The constant-tension spring has, however, been developed mainly as it has the broadest field of practical application. These springs are stated to be most useful when employed at high stresses, being capable of the greatest efficiency when very high cycle life is not required. Each spring is supplied in the form of a tight roll of metal tape and such springs have a particular advantage in their degree of usable extension, which can be up to fifty times the diameter of the coiled roll. They can be used effectively when curved round corners and through small openings in a similar way to non-elastic bands or cables.

When the springs are in use a very slight load variation is stated to occur due to build-up of the strip on the spool. It is possible to eliminate this effect by careful variation of the radius of the set on a spring. It is, however, considered to be negligible for practical applications, as a typical spring, with a designed effective life of 10,000 cycles extended to thirty times its original diameter, undergoes a load build-up of only about 5 per cent.

The springs can be arranged in various ways to provide long-running, constant-torque motors and two forms of these motors are shown diagrammatically below the drawing of the spring. In the motor on the left, the spring is mounted on a freely rotating drum and is wound on to a larger drum by an appropriate drive. This second drum holds its coils only so long as it is prevented from rotating. On the braking force being removed the tendency for the spring to recurl to its preset curvature causes it to rewind on to the smaller drum. As the spring recurls it imparts a constant output torque to the shaft of the larger drum. A motor of this design is suitable for driving a low-power mechanism and has a long working life.

To provide a more powerful drive of similar size, but one which has a shorter working life, the second design of motor shown on the left can be used. In this motor the spring is wound in the reverse direction on the larger drum and this reverse bending serves to increase the working stress in the spring material.

Nucleonic Level Indicator

We illustrate a new instrument which employs gamma radiation for indicating contents levels. It is made by Baldwin Instrument Company, Ltd., Brookland Works, Dartford, Kent.

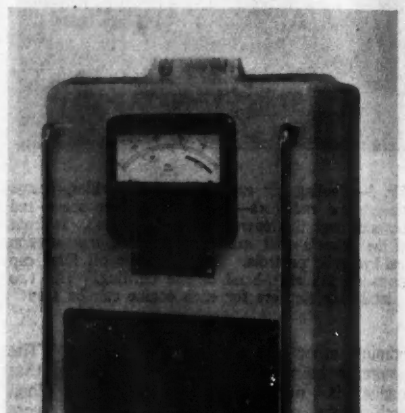
The principle of this method of indicating levels in a container is to place a gamma emitting isotope on one side of the container and a detector on the other. Radiation passes from the isotope, through the container to the detector, which is a geiger counter. The output from the detector is proportional to the amount of radiation which it receives. When the contents are below the radioactive "beam," maximum radiation will be received by the detector; when the contents rise and cut the "beam," the radiation reaching the detector will be substantially smaller. The difference in radiation reaching the detector is shown as a difference in electrical output from the geiger counter, and this difference is arranged to operate a relay, as described below. The indicator unit shown in the illustration houses the relay and two lamps which indicate whether the "beam" is broken or not. For complete control, two heads can be fitted to the container, thereby giving indication when the contents reach maximum and minimum levels; alternatively, a movable head can be fitted.

As the operation of the relay depends on the difference in radiation, it is possible to detect the boundary between, say, two liquids having substantially different densities. On the other hand the instrument will not function where the mass of the material in the beam is very low compared with the mass of the walls.

The detector consists of a G.M. tube, a head amplifier and an integrator. When the G.M. tube is subjected to radiation, electrical impulses are produced, the frequency being proportional to the intensity of radiation reaching the tube. The pulses are amplified by the head amplifier and fed to the integrator, which transforms them into a unidirectional voltage, the magnitude of which is dependent on the number of pulses per second.

The next stage in the instrument is a discriminator which is an electronic relay arranged to operate when the voltage from the integrator reaches a certain level. When the discriminator operates, a current is allowed to flow through the power amplifier and thence to an electromagnetic relay, which operates. The contacts of this relay can be used to control either the indicator unit (visual or audible signalling) or an automatic control system, or both. A common source of power is supplied by the power pack. A test meter is fitted which can be switched into the important parts of the circuit for fault detection.

Assuming, for example, that the detector head is so mounted as to indicate when material in a container reaches a predetermined low level, the operation of the system is as follows. Normally the radiation from the radioactive source will have to pass through both the walls of the container and the material and will be attenuated by an amount dependent on the total mass of material in the radioactive beam. The equipment is so arranged that in this condition the voltage output from the integrator will not be large enough to operate the discriminator. The relay will thus remain in the normal condition.



Gamma radiation is used in this instrument to indicate the level of the contents of a container

When the level of material drops below the radiation beam, the intensity of radiation reaching the G.M. tube is increased, causing an increase in the number of pulses per second, thus producing a higher voltage output from the integrator which operates the discriminator. The output from the discriminator is fed via the power amplifier to the relay which, in turn, supplies the necessary signal to the indicator unit or the automatic control system.

Air-Operated Vice.—An air-operated machine vice, made by the Hardon Precision Engineering Company, Ltd., Manor Estate, Church Road, Thundersley, Essex, has jaws 4½in wide by 1⅞in deep, with a maximum opening of 2 11/16in. Its sliding jaw has a working movement of ⅛in under compressed air operation and is positioned in respect to the work through a lead-screw turned by a handle. The air cylinders, designed to work with an 80 lb/100 lb per square inch line pressure are enclosed within the body of the vice.

Industrial and Labour Notes

Wage Claims

On Thursday of last week, representatives of the Confederation of Shipbuilding and Engineering Unions formally presented to the Engineering and Allied Employers National Federation a claim for a 10 per cent increase in the wages of adult male workers in the engineering industry. In receiving the demand, the Federation recalled its earlier statement about the dangers of inflation and the rejection of any new claim brought forward. It was stated, however, that the Federation would circulate the details of the unions' claim to its member firms. A claim, in similar terms, on behalf of shipbuilding workers, was submitted on Tuesday to the Shipbuilding Employers Conference.

Last week, the British Employers' Confederation issued a statement about wage claims, pointing out that in industry as a whole wages were the largest single element in costs, and that a general increase in wages at the present time would be "self-defeating." It would itself induce a further rise in prices, the statement continued, and the United Kingdom was not at present exporting enough to safeguard her standard of living. The competitive power of other nations was increasing and the United Kingdom's share of world trade had fallen, the Confederation commented. Between 1950 and 1955, average labour costs per unit of output in the United Kingdom rose by 29 per cent, in the U.S.A. they rose by 10 per cent, and in Western Germany by only 2 per cent. Further wage increases in the present circumstances, the statement urged, would still worsen that position, and higher earnings could only be justified where they did not increase the cost of goods or services. The statement ended with an expression of the Confederation's unanimous opinion that no general wage increases, nor any general change in terms of employment, which in either case would increase costs, could be justified.

Contracts of Service

The quarterly meeting of the Minister of Labour's National Joint Advisory Council was held in London on Wednesday of last week. It was attended by representatives of the British Employers' Confederation, the Trades Union Congress, and the boards of the nationalised industries.

At the meeting, the Minister of Labour, Mr. Iain MacLeod, mentioned the ideas which he had put forward concerning the period of notice and the contract of service. He said that he was anxious to move with all reasonable speed, but what he had in mind was essentially a long term proposal. His Ministry had been studying that proposal for some time, and he himself wanted soon to have informal talks with both sides of industry prior to having a more formal meeting. The Minister made it clear, however, that any initiative by himself in this particular matter did not in any way indicate a change in the attitude of the Government towards the desirability of leaving industrial negotiations entirely to the two sides of industry. His hope and belief were that it would be possible to achieve what he had in mind without legislation, and through the ordinary processes of negotiation and agreement.

Another matter before the council was an interim report on the replies received so far in response to the approach to industry on the efficient use of manpower. It was stated that forty-one industries had replied, but that information was still awaited from a number of important industries.

Industrial Films

Last week, the Workington Iron and Steel Company branch of the United Steel Companies, Ltd., showed, in London, its colour film entitled "Steel Road." The film was produced by Wallace Productions, Ltd., as a tribute to the work of Sir Henry Bessemer, and opens with references to some of his early inventions. The gradual development of his method of making steel, the mining of the pure hematite ore in Cumberland, the complete process of the "blow" in the converter during which the iron is converted into steel, and the final teeming into moulds and heating in soaking pits, prior to rolling, are shown in considerable detail. Sequences depicting the passage of the hot ingots through the rolling mills and their gradual transformation into rails are followed by a short track-laying demonstration.

Another film, which was also shown in London last week, is one produced for the British Iron and Steel Federation and entitled "Birth of a Car." This film draws attention to the close tie between the steel industry and the motor car industry, pointing out that the car body building plants are amongst the largest consumers of steel in the country, an average of about one ton of finished steel being used in the production of a modern motor car. Stages of production in the manufacture of a car are shown, and in relation to each process many of the tests and much of the research necessary to produce the more than thirty different kinds of steel used, are demonstrated.

Both the films are available in 16mm and 35mm sizes.

Economic Statistics

The Association of British Chambers of Commerce recently asked the Government for certain assurances concerning the collection of economic statistics. This request followed a statement by the Chancellor of the Exchequer, in August, that the statistics available often did not provide enough up to date knowledge of economic changes. The Association of British Chambers of Commerce agreed to do what it could to make a success of improving statistical information.

The Association, however, was anxious to be assured on certain points. It says that the Government has now stated, for example, that it will only call for information which does not normally arise in the course of business, unless such information is absolutely "vital." Another assurance which has been given is that it is the Government's policy in initiating any statistical inquiry to consult with trade associations as to what information it is practical to collect. Furthermore, the Association has been assured that the policy is to publish the results of official inquiries as quickly as possible in order that industry and commerce should be as well informed as the Government itself.

Registering Restrictive Trading Agreements

The Registrar of Restrictive Trading Agreements (Chancery House, Chancery Lane, London, W.C.2), has made regulations, under the Restrictive Trade Practices Act, 1956, which specify the documents to be sent to him for the purposes of the register. Briefly, these are any document constituting an agreement or part of it, and a memorandum setting out any terms of an agreement, and the names of any parties to it which are not in such a document. These documents (four copies will be required) must be accompanied by a certificate on a form, to be issued by the Registrar, stating that they contain the whole of the terms of the agreement and the names of all parties to it. The period allowed for the sending of particulars of agreements of the classes "called up" by the Registration of Restrictive Trading Agreements Order, 1956, is from November 30, 1956, until February 28, 1957. No particulars have to be sent of agreements of those classes terminated before November 30th, or in the case of agreements made before August 2nd last and terminating on February 28, 1957.

A *Guide to the Registration of Agreements under Part I of the Restrictive Trade Practices Act*, 1956, was published yesterday (H.M. Stationery Office, price 1s.). It is a technical handbook intended to help those who are required to furnish particulars of agreements. The book contains chapters dealing with the kinds of agreements which are registrable, the documents which must be sent to the Registrar, and the position of trade associations under the Act. When it is prepared, the Register of Agreements will be maintained in London, Edinburgh and Belfast, and will be identical in all three cities. That stage will not be reached yet, however, since the register will not be made until a substantial number of agreements has been received and examined.

C.E.A. Consultation Machinery

Changes in representation on the National Joint Advisory Council and the twelve district joint advisory councils covering the electricity supply industry in England and Wales have been announced by the Central Electricity Authority. As from April 1, 1957, the councils will include employees who are already elected by their fellow workers to represent them on the local advisory committees.

At present, the national and district councils consist of representatives of the C.E.A. and the area electricity boards and of the ten trade unions. In future, in addition to those members, the national council will select, from nominations forwarded from each district, twelve representatives elected by local advisory committees, who will sit on the national council for a period of two years, subject to their remaining members of their own local advisory committees. Similarly, each district council will select ten representatives elected by the local advisory committees, who will be members of the district council for a period of two years. Other changes which are to be made include one which renders it obligatory for all local advisory committees to present annual reports on their proceedings.

Iron and Steel Industry's Productivity

The British Productivity Council has published a review of progress in the British iron and steel industry, in which it is explained that between 1946 and 1955 productivity increased by 41 per cent. The main contribution to increased productivity in this industry in recent years, of course, has been made by maintaining capital investment in plant and equipment at a high level. The review points out that, since the end of the war, capital investment in iron and steel has amounted to £470 million, and the total amount invested for every worker in a new integrated steel works now stands at a figure of £10,000. But the review goes on to say that even if each ton of steel now involves a heavier call on the nation's resources of capital (and it is by no means certain that it does), the investment in new plant and equipment has so reduced the call on labour, fuel and raw materials that the total real cost of steel is now less.

The review goes on to show that capital investment has not been the only reason for higher productivity, and due credit is given to other factors, such as economy in the use of plant, fuel and raw materials, and also to effective management. Emphasis on the role of capital investment, the review says, must not be taken as suggesting that the steel industry is not closely concerned with the standard of its labour force. Such investment, while reducing the quantity of labour that goes into steel, makes its quality vital.

Nevertheless, the review concludes, although the iron and steel industry has a fine record in productivity, there is no room for complacency. All the leading industrial groups—the U.S.A., the European Coal and Steel Community, the U.S.S.R. and Japan—are planning heavy investment programmes in steel, and the review stresses that the British steel industry "will have to fight hard to maintain its position." The success of its productivity campaign since the war must be a spur to further effort, and not an excuse for inactivity in the years ahead.

European Coal and Steel Community

No. II—(*Concluded from page 599, October 26th*)

General Levelling-Up in Production and Consumption

ANOTHER characteristic of progress in integration is the gradual shrinkage of existing disparities in economic standards between the different areas of the common market. It is clear that if the general level varied too much between one area and another this would only have an adverse effect in the long run upon the development of the whole.

Some progress has been achieved in this respect, too, but it is impossible to separate the direct effects of the common market from other factors; the whole matter is bound to be a gradual process extending over many years.

Among the main features of the years 1952–55 may be noted particularly the progress made by Italy's industrialisation, especially in the south. In the years under review Italian crude steel production rose by 53 per cent, compared with 23 per cent for the other Community countries. During the same period, steel consumption rose by 44 per cent and in other countries by only 28 per cent. The actual annual consumption per head of population is, however, still lower than elsewhere.

TABLE IV—*Crude Steel Production and Steel and Energy Consumption in Italy compared with the Remainder of the Community*

Year	1950	1951	1952	1953	1954	1955
Steel production (million metric tons):						
Italy (1952=100)	—	—	3·54 (100)	3·52 (99)	4·21 (119)	5·40 (153)
Others (1952=100)	—	—	38·28 (100)	36·18 (95)	39·62 (104)	47·26 (123)
Annual steel consumption per head of population (kilogrammes):						
Italy (1952=100)	64 (75)	76 (89)	85 (100)	91 (107)	105 (124)	122 (144)
Others (1952=100)	200 (77)	222 (85)	261 (100)	254 (97)	279 (107)	333 (128)
Energy consumption per head (hard-coal equivalent, kilogrammes)						
Italy (1952=100)	642 (82)	773 (99)	779 (100)	837 (107)	917 (118)	983 (126)
Others (1952=100)	2646 (88)	2963 (99)	2995 (100)	2934 (98)	3100 (104)	3321 (111)

Table IV indicates the rapid growth of Italian crude steel production, steel consumption and energy consumption, in comparison with the rest of the Community countries. Differences in energy consumption are, of course, to some extent due to the milder Italian climate, as well as to the smaller degree of industrialisation.

Wages

Wages in the iron and steel industries of the Community have, almost without exception, increased more than those in the entire processing industry in each country. Up to the present the increase in earnings has been higher in those countries which in 1952 did not belong to the group paying the highest wages. Hourly gross earnings of the steel workers rose faster than in the processing industry generally in Germany, the Saar, and the Netherlands, and remained more or less the same in Belgium and in France. Only in Italy were they slightly lower. According to the High Authority's figures, real incomes of Community workers in 1953 were highest among Luxembourg and Belgian steelworkers. Germany, the Netherlands, the Saar and France varied according to circumstances and the pattern of consumption at 75–85 per cent of the Belgian standard, with Italy rating a bare 70 per cent.

Exports to and Imports from Third Countries

Quantitatively, exports of treaty products have risen considerably since 1952, and in value they have regained the 1952 level. The export and import figures are quoted in Table V. Scrap and iron ore are not shown as they represented only 1·5 and 0·5 per cent of the total tonnage of exports in 1953. Imports also rose, proving that the introduction of the common market did not cause a tendency towards economic isolationism.

TABLE V—*Trade in Treaty Products with Third Countries (millions of metric tons)*

	Exports					Imports				
	1952	1953	1954	1955	Increase 1952/55, per cent	1952	1953	1954	1955	Increase 1952/55, per cent
Hard coal, briquettes, coke	9·78	10·36	13·50	15·53	+59	22·3	13·8	13·9	23·1	+3
Iron ore	—	—	—	—	—	13·8	14·2	12·6	18·5	+34
Scrap	—	—	—	—	—	0·5	0·5	0·5	2·5	—
Iron and steel	8·19	7·96	8·10	9·72	+19	0·9	1·0	1·1	1·7	+83

Investment Policy

From the first it was clear that it was necessary to increase the coal production of the Community in order to meet the rising demand and reduce coal imports; to run the iron and steel industry competitively, so as to maintain exports and thereby pay for essential imports; and to construct essential housing for the workers. Expenditure on these heads during the coming four or five years will be of the order of 400–500 million dollars for iron and steel, 400–450 million dollars for the coal mines, and 250–300 million dollars for housing.

For firms to raise these sums themselves was difficult because of high interest rates for long-term loans, amounting to 8–10 per cent per annum, compared with up to 5 per cent in the United Kingdom, and 4 per cent in the U.S.A. Government assistance also was limited by the cost of rearmament.

The treaty, therefore, empowered the High Authority to grant loans to undertakings or to guarantee loans granted to them for improving their productive capacity.

By the provisions of the treaty, the High Authority was empowered to levy a percentage from current production which rose in stages to its maximum of 0·9 per cent. The sums which thus became available are for administrative expenses, technical and economic research, certain grants and the remainder for investment.

An inquiry at the beginning of 1954‡ established the pattern of investment and methods of raising capital in the various branches of the iron and steel industry and of coal mining. A serious diminution of the rate of investment was noted above all, in the case of underground coal mines, and also with thermal power plant for mines and steel works, briquetting factories, steelmaking, and coal treatment plant. Apart from briquetting, the lignite industry was progressing well, while iron ore mining and iron and steel appeared to be slowing down. The inquiry also showed that 75 per cent of the funds invested were obtained by abnormal methods, such as short-term loans, American aid and public funds. The total annual charges for interest and depreciation which this outside financial assistance involved amounted for the coal industry alone to 45,000,000 U.E.P. dollars. The re-establishment of normal ways of raising capital, was therefore, a fundamental matter for the Community on which its future depended. On April 24, 1954, the Iron and Steel Community was able to obtain an American loan of 100 million dollars.

In its financial policy the Authority aimed at playing a complementary role, and to leave the responsibility for their programmes entirely to individual firms. Loans were granted for projects in certain sectors costing at least 500,000 dollars, and had to be spent before the end of 1955. The terms were up to twenty-five years, with a rate of interest around 4½ per cent.

On July 20, 1955, it was made compulsory for firms belonging to the coal and steel sector to notify the Authority of their investment programmes where these involved an expenditure of over 500,000 U.E.P. dollars in the case of new installations or over 1,000,000 U.E.P. dollars in the case of replacements or alterations.

As in preceding years, the Authority has obtained details of the investment which took place last year or are projected for 1956/59. These are summarised in Table VI. They are designed to increase the production of coal from 242 million tons in 1954 and a rate of 251 million tons per annum during the first quarter of last year, to 265 million to 270 million tons in 1959.

TABLE VI—*Investments*

	Millions U.E.P. dollars		
	Total on January 1, 1955	Scheduled for	
		1955	1956/59
Hard coal:			
Mines	663	303	459
Power stations	313	214	249
Collieries	159	51	107
Briquetting plant	7	11	7
Total	1142	579	822
Lignite:			
Mines	500	—	—
Briquettes, semi-coke	37	—	—
Iron ore:			
Mines	72	39	46 (1955/58)

At the same time, generating capacity is to be raised from 5880MW in January, 1955, to 8000MW to 8500MW in January, 1959. Coke production is to increase from 58,000,000 and 66,000,000 tons per annum achieved during 1954 and the first quarter of 1955, respectively, to 76,000,000 tons per annum at the beginning of 1959.

Investments in the brown coal industry increased to the very considerable figure of 500 million dollars at the beginning of 1955. Briquetting and semi-coke accounted for another 37,000,000 dollars, the investments being intended principally to preserve the actual capacity of 16,000,000 tons of lignite briquettes per annum.

Total investments in the iron ore industry on January 1, 1955, amounted to 76,000,000 dollars, and new investments scheduled for 1955 and 1955/58 amounted to 39,000,000 and 46,000,000 dollars, respectively. This is designed to raise the output of ore from 65,000,000 tons in 1954, and a rate of 70,000,000 tons per annum during

‡ High Authority, Second General Report, pages 149–156

the first quarter of 1955, to 85,000,000 to 86,000,000 tons per annum in January, 1959.

At the beginning of last year, the total investments in the iron and steel industry amounted to 1280 million dollars and the additional sums for 1955 to 626 million dollars. It is hoped by this accelerated development to increase the iron smelting capacity by 1959 to 4,500,000 tons per annum, or 11·5 per cent above 1955, and so reduce the gap between iron production and steel-making.

Steel-making capacity is now expected to increase by 6,600,000 tons by the end of 1957, of which 13 per cent is for Siemens-Martin steel, 11 per cent for Thomas steel, and 28 per cent for electro steel. Extension of rolling mill capacity will be at least 8,900,000 tons per annum.

Labour

The chief objectives of the treaty, increased production and consumption, imply a raising of the living standard of the workers. Certain basic principles of labour policy are laid down in the treaty, which it is the task of the High Authority to put into effect. The Authority has to gather information on living and working conditions, raise the mobility of the labour force, prevent wage undercutting, and take measures against unemployment resulting from technological improvements.

The High Authority, accordingly, is taking action along the following lines. It prepares an inventory of the labour forces in the coal and steel industries, seeks to obtain mobility of labour (such as by establishing classifications of trades and employment exchanges), and the putting into effect of a multilateral convention on social security; the Authority also studies wages and working conditions, training of workers, and housing schemes. It has made available the sum of 1,000,000 U.E.P. units for the construction of 1022 experimental houses, of which 350 had been completed last November.

By obtaining long-term loans from German, Belgian and Luxembourg banks, it succeeded in raising finance for 25 to 50 per cent of the original programme in those countries. The revised schedule provided for the building of 10,000 houses in Germany (at a total cost of 6,100,000 dollars), 1600 in Belgium, and 25 in Luxembourg. At the end of last year, negotiations were in progress in France, Italy and the Saar to obtain similar loans to a total of 1,800,000 dollars. Part of the cost of the houses (about one-quarter) is advanced by the Authority, the remainder by the government of the country, industry, and others.

A Committee for Industrial Hygiene and Medicine has been set up, with the main objectives of combating silicosis and other occupational diseases, and of rehabilitating handicapped workers. A sum of 300,000 U.E.P. dollars is to be devoted to a four-year programme of research.

Technical and Economic Research

The High Authority has the task of encouraging research into technical and safety aspects of its industries, and part of the levy is to be devoted to such purpose. Specialised committees (on mining, coke manufacture and iron and steel-making) have been meeting in Luxembourg since April, 1953, and contacts with many technical agencies have been maintained.

Last autumn a research project was initiated concerning blast-furnace coke, with a grant of 1,000,000 U.E.P. dollars. Another research programme, involving 278,000 U.E.P. dollars, concerns silica bricks for the roofs of Siemens-Martin furnaces. Other topics of research include the effect of the properties of coke on the operation of blast-furnaces, improvement of refractories, influence of temperature on the quality of rolled products and running tests of pressurised blast-furnaces. In July, 1955, the International Flame Research Committee was given a grant of 105,000 U.E.P. dollars to enable it to intensify its work. The committee comprises, besides the Community countries, Great Britain, Sweden and the U.S.A. It maintains a research station at Ijmuiden,§ with experimental furnaces for liquid and gaseous fuels and for pulverised coal.

§ See THE ENGINEER, June 20, 1952, page 822; May 7, 1954, page 684; November 25, 1955, page 756, and December 2, 1955, page 808.

Lorry Loader

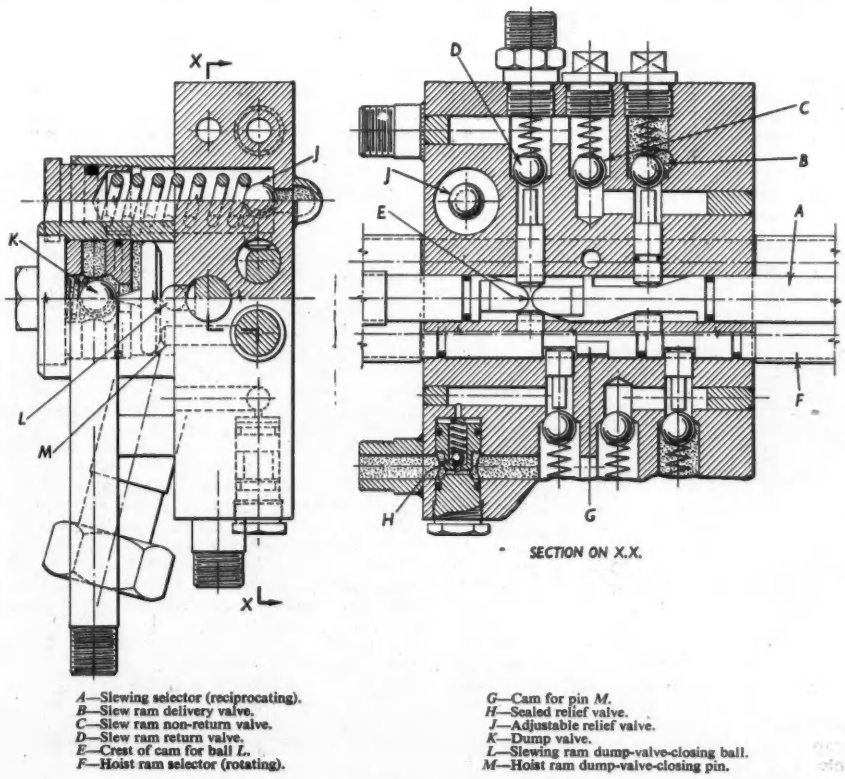
A hydraulic lorry loader with a maximum capacity of 2 tons has been developed by Hydrauliska Industri Aktiebolaget. It can be clamped to the chassis of a commercial vehicle, needing only a space of 15in between cab and body to accommodate it. It draws its power from a compact sixteen-plunger swashplate pump which is driven from the power take-off, and which absorbs 7 h.p. at 400 r.p.m.

As can be seen in the illustration, the loader consists essentially of a crane with an articulated jib. Within the upper portion of the jib there is a telescopic extension which can be drawn out, in stages, by the operator to give a maximum radius of 13ft 3in: a safety factor of 3 gives a working load of 1 ton in this condition. A chain anchored at the end of the extension can be clamped to give any desired depth of plumb: for the heavier loads that can be handled at radii down to 5ft, a sheave is used in the bight of the chain. The ram that luffs the upper portion of the jib is controlled by the lever seen in the driver's left hand: the ram extends far enough to align the two portions. The maximum height is about 23ft.

Fig. 1—Hydraulic lorry loader in action: notice that the main ram can lie within the pillar when the jib is folded down

The lower part of the jib is luffed by a larger ram controlled by the lower lever. This lever also controls the slewing of the crane pillar by two rams at the ends of a rack: all control movements are instinctive, the latter lever moving in the fore-and-aft plane for luffing and the transverse for slewing. The crane is stowed for travelling by folding the upper jib upwards to lie on top of the lower portion, and luffing the jib right down into the space between the left-hand front corner of the body and the cab: it fits so closely into a 7ft 6in overall width that the luffing handle is made removable to allow "Raise" to be selected.

The pillar is mounted upon a fabricated



A—Slewing selector (reciprocating).
B—Slew ram delivery valve.
C—Slew ram non-return valve.
D—Slew ram return valve.
E—Crest of cam for ball *L*.
F—Hoist ram selector (rotating).
G—Cam for pin *M*.
H—Sealed relief valve.
J—Adjustable relief valve.
K—Dump valve.
L—Slewing ram dump-valve-closing ball.
M—Hoist ram dump-valve-closing pin.

Fig. 2—Control block for slewing and both hoisting rams (full pump pressure in stippled areas)

box-section transversal that acts as the oil tank : there is a visible level device. At its ends this carries two spring-retracted rams which can be made to take the weight of the front of the vehicle by opening the valves leading to them and loading any of the other hydraulic rams : the valves are subsequently closed. In this condition the crane does not impose torsional loads on the chassis.

A single valve block controls all motions, and is so arranged that the pump is unloaded when idling. In Fig. 2 a ball, spring-loaded on to a seat, can be seen, past which the pump delivery returns to the tank ; this ball is unseated by a lever supported on two pins and a ball. As soon as the jib rams are selected " up," or the slewing selector is moved in either direction, the pins or the ball, respectively, retract, allowing the lever to tilt and the ball to seat, so that the pump output pressure rises to that determined by the adjustable relief valve adjacent to the by-pass and by the pump speed—a hand accelerator adjoins the selector levers. Further movement of the selector concerned opens one of the ball valves against pump pressure and feeds oil to the appropriate ram : there is in each case a non-return valve, since operation of a second circuit might lower the oil pressure below that needed to sustain the applied load. As can be seen in the drawing, there is in each group a third ball valve : this is opened to empty the closing slewing ram, or to allow the luffing rams to lower.

The upper selector, seen operating four valves for the slewing rams, reciprocates along its axis : the others rotate. An attractive detail of the design is the use of flow limiting valves at the cylinder ends of the flexible hoses on the boom : these close against a spring if the load is lowered too quickly or, of course, if there is a leak in the piping from the valve block. These valves then support the jib until " Raise " is selected to unseat them. There is a sealed relief valve in the control block which sets an absolute limit to the pressure available.

The loader, which weighs 1450 lb, is known as the H.I.A.B. " Major," to distinguish it from the 1-ton " Minor," in which a telescopic boom, power slewed and pivoting on a hydraulic ram, lifts by a combination of luffing and rope reeving. A number have already been built and oil leaks from the rams have, it is claimed, been eliminated by the adoption of synthetic seals. In action, the loader appears to be amply powerful and easily controlled : because it is clamped only to a very short length of the chassis, it wracks visibly relative to the body. Although it adds about 25 per cent to the cost of a vehicle such as that illustrated, it may raise the utilisation of the truck markedly by rendering the drivers independent of terminal facilities : it also has such uses as erecting lamp-posts. It was demonstrated to us by George Cohen, Sons and Co., Ltd., Wood Lane, London, W.12.

Opening of European Computer Centre

On October 19th the official opening took place of the " Univac-Europe " computer centre at the Battelle Institute, Frankfurt-on-Main. The principal equipment, a Remington Rand " Univac I " computer weighing nearly 20 tons, had been brought by air from New York at the beginning of August.

The " Univac " computer goes back to the " Eniac," built in 1945 at the University of Pennsylvania by P. Eckert and J. Mauchly, and further developed into the " Binac." The first " Univac " came into operation at the U.S. Bureau of Statistics in March, 1951.

The machine comprises three main sections, viz., the input and output sections and the computer itself. The latter consists of the programme control unit, the arithmetic unit, the inner information store, of small capacity but giving fast access to information, and the outer store, giving slower access but having a much larger capacity.

In the " Univac I " the inner store takes the form of mercury delay lines, while the outer store is a magnetic tape. A further development, the " Univac II," differs in the main from the " Univac I " by having a magnetic core inner store, which has twice the access speed and, moreover, has the advantage that failure of the power supply does not cause the stored information to disappear.

For input and output the Frankfurt machine makes use of magnetic tape, which is coded in special machines by using punched cards, perforated paper ribbon, or by typing the information on the keyboard of a special typewriter which at the same time allows a typed record to be obtained.

The tape machines, called " Uniservos," can be connected ten at a time to the computer, which can simultaneously operate with four tapes (one being read, one written on, and the remaining two being rewound). Each tape can hold up to 1,440,000 symbols at a density of 128 symbols per inch, and can be read at a speed of 12,800 symbols per second. Each tape holds 2000 blocks of 720 symbols each and can be read or written on at a speed of 100–104 milliseconds per block.

Between the input unit and the computer, and output unit and computer, buffer units are fitted, which have a capacity of sixty words (=720 symbols).

The inner (fast) store comprises 100 mercury delay lines, each of which can hold ten words consisting of twelve symbols each, so that there is a total storage capacity of 12,000 symbols. Minimum time of access, including transmission, is 40 microseconds; maximum time is 445 microseconds.

The final output can be obtained either in the form of punched cards, perforated tape, or paper printed by electric typewriter or high-speed printer. The maker has developed a high-speed printer, which achieves the remarkable speed of ten lines each of 130 characters per second or 78,000 characters per minute. A complete alphabet and symbols is carried on the edge of each of 130 coaxially mounted discs, which rotate at high speed. An impression of a letter is obtained by hitting the reverse side of the paper with a very light electromagnetically operated hammer. The correct instant of operation is obtained electronically after the letter has been preselected by the magnetic tape. Typographical errors are avoided by comparing optically-electronically the chosen letter with the corresponding letter on a special checking disc carried on the same shaft as the printing discs, and checking from the echo of the hammer blow that the hammer has operated correctly. A complete line is thus printed with each revolution of the shaft.

With numbers of eleven significant figures the " Univac I " is stated to be able to carry out per second 1900 additions or subtractions, 2250 transfers, 2740 comparisons, 465 multiplications, and 257 divisions. Its accuracy of operation is safeguarded by having the arithmetic units duplicated. All calculations are thus carried out in duplicate and are continuously being compared by the checking circuits which constitute a large portion of the computer (about 30 per cent).

Our illustration shows the installation, which is available to anyone in Europe. The computer, which is claimed to be the first large one on the Continent, is stated to be specially useful for business problems, besides its applications to science and industry. A total full-time staff of about thirty persons is required, including office staff.

" Univac-Europe " computer at Battelle Institute, Frankfurt-on-Main

Moisture Content Meter

For the automatic measurement and control of the moisture content of materials such as paper, wood, textiles and grain, Panelektrik OHG, Ullmannstrasse, 13, Vienna XV, has produced an instrument based on the variation of electrical resistance. The measurements are stated to be independent of electrolytic or stray leakage currents. Built for operation by mains current, the equipment is stable and unaffected by changes in the supply voltage up to ±25 per cent. The standard measuring ranges vary according to application, from 0·02 to 2 per cent of water content for sugar, to 8 to 25 per cent (maximum, 35 per cent) for tobacco. The tolerance of the measurements varies correspondingly, from ±0·002 per cent to ±0·3 to 0·8 per cent. A smaller and more readily portable design, built for battery operation, is also available. A number of different electrodes are made to cover a variety of applications. In the case of continuous control the electrodes are lifted off the material if the feed is interrupted. The electrodes are designed to avoid damage to the material under treatment. Special constructions are available to control a number of mutually independent parameters, such as the supply of warm air or the feed rate, either singly or in combinations. Automatic temperature compensation is built in, and there is a connection for a recorder.

Radio-Telephony in Railway Marshalling

An experiment involving the use of radio is at present taking place in the goods yard at Miramas, near Marseilles, with the purpose of facilitating the work of the checkers. On the arrival of trains, the checkers are responsible for checking the number of each wagon, the weight of the load, and the destination of the goods. According to a report in this month's issue of the *C.I.C.E. Information Bulletin*, the checkers at Miramas have been equipped with portable F.M. sets operating on 160–161 Mc/s which weigh only 3·2 kg and can work for five hours. They are fitted with loudspeakers which also serve as microphones, thus allowing the user to have both hands free.

The messages are received at the rolling stock office, where they are either taken down or recorded on a "magnetophone." The office is equipped with a 20W transmitter, two receiving sets in service, two standby sets, and " magnetophones."

U.S. Air Force Radar Station on Georges Bank in the Atlantic Ocean

BY OUR AMERICAN EDITOR

The design and construction of the "Texas Tower No. 2" U.S. Air Force Radar Station on Georges Bank in the Atlantic Ocean, 160 miles east-south-east of Boston, represents an unusually difficult civil engineering scheme. The steelwork for this radar platform was fabricated in a shipyard ashore and was then towed to the site. The final erection was accomplished with the aid of several DeLong air jacks, which raised the deck to the desired level by climbing up the caissons.

THE first of the various off-shore radar stations for early aircraft warning which are being constructed for the U.S. Air Force in the Atlantic Ocean off the American coast was recently completed. It is illustrated in Fig. 1 and is officially known as U.S. Air Force Station, Georges Bank, Texas Tower No. 2. It has been under design and construction since early 1955.

The idea of constructing radar islands off the New England coast for early aircraft warning was an outgrowth of the Lincoln Project at the Massachusetts Institute of Technology. Off the coast there are fishing banks and extensive shoal areas surrounded by waters of great depth. The basic idea was to use certain shallow areas for radar-equipped platforms. Although such installations would be U.S. Air Force facilities, their construction would be a marine operation. Consequently, the Bureau of Yards and Docks of the U.S. Navy was selected to determine the feasibility of building such radar platforms and, subject to its conclusions, to contract for the design and construction of a limited number. The proposed radar platforms have now become known as "Texas Towers," because of their resemblance, in certain respects, to the oilwell platforms constructed in the Gulf of Mexico.

The first step undertaken by the First Naval District, at Boston, was to engage a group of consultants to investigate the many problems and to submit a feasibility report covering five selected sites. The advice and assistance of the Woods Hole Oceanographic Institute were of great value to all concerned in these and subsequent studies. Since a knowledge of the geology and soil conditions of the shoals was essential for the design of the foundations, a contract was negotiated by the First Naval District under which borings were made on two of the selected sites, one at Georges Bank and the other on Nantucket Shoal. These were the only two sites on which it was practical to make borings in the pre-hurricane season of the summer of 1954. The borings revealed the soil conditions to depths of 120ft below the ocean floor.

Texas Tower No. 1 will be situated in 50ft of water on Cashes Ledge, a rock outcrop 75 miles east of Portland, Maine. Texas Tower No. 2, the first one completed, is situated on Georges Bank in 56ft of water, 160 miles east-south-east of Boston. Texas Tower No. 3 will be situated 80 miles south-east of Nantucket in 80ft of water. Texas Tower No. 4 will be off Long Island, 70 miles east of Ambrose Light in 180ft of water, and Texas Tower No. 5 will lie 200 miles east of Boston on Browns Bank, in 130ft of water. The shoal areas under consideration have appeared on mariners' charts as far back as such charts have been in existence; it therefore seems unlikely that the banks will move or become subject to erosion.

The construction methods which have to be employed in the North Atlantic bear no resemblance to harbour or coastal operations. There is never any slack water between tides. The tidal currents run from 3 to 5 knots and continually change direction so that they rotate clockwise through a full circle every twelve hours. There is never a dead calm. Ground swells are continuous and of various heights. Superimposed on the swells are the local wind waves, resulting in total wave heights of 6ft to 8ft on the best of days. At times the waves are 35ft high with winds up to 60 m.p.h. Another aspect of these shoal areas is that they are shrouded in fog for a considerable part of the time. To navigate them, ships must be equipped with "fathometers," radar and "loran" instruments.

Design of Tower

The tower platform is a triangular structure, approximately 200ft long on each side, with a height of 20ft, thus providing two decks. The upper deck contains the living quarters, galley, mess hall and recreational facilities, and the lower deck the power plant, boiler-rooms, fuel and water tanks and storage space. Covering a part of the main deck is a deck-house 60ft wide and 200ft long, containing offices and operational facilities, and suporting the three radomes, the equipment in which is classified. Other facilities on this deck are the aerial masts, two 80ft derricks with constant-tension winches, and disc antennas. That part of the main deck outside the deck-house is kept clear of obstructions for the use of helicopters. Under the platform there is a revolving bridge to permit access to all underside facilities as well as to the three supporting caissons.

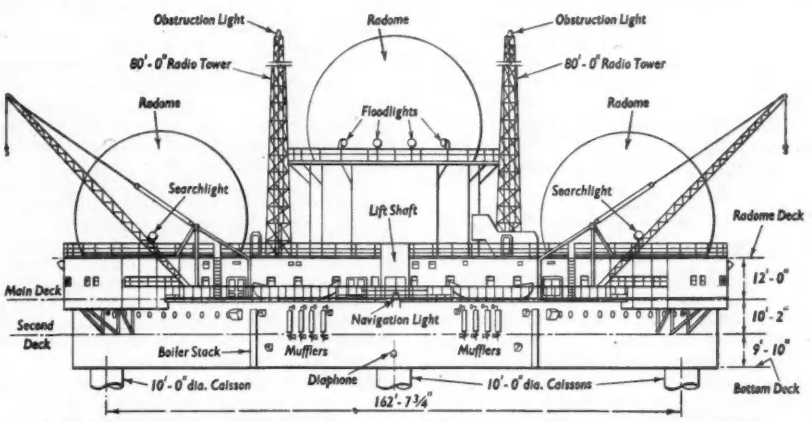


Fig. 2—General arrangement and structural design of radar platform on Georges Bank

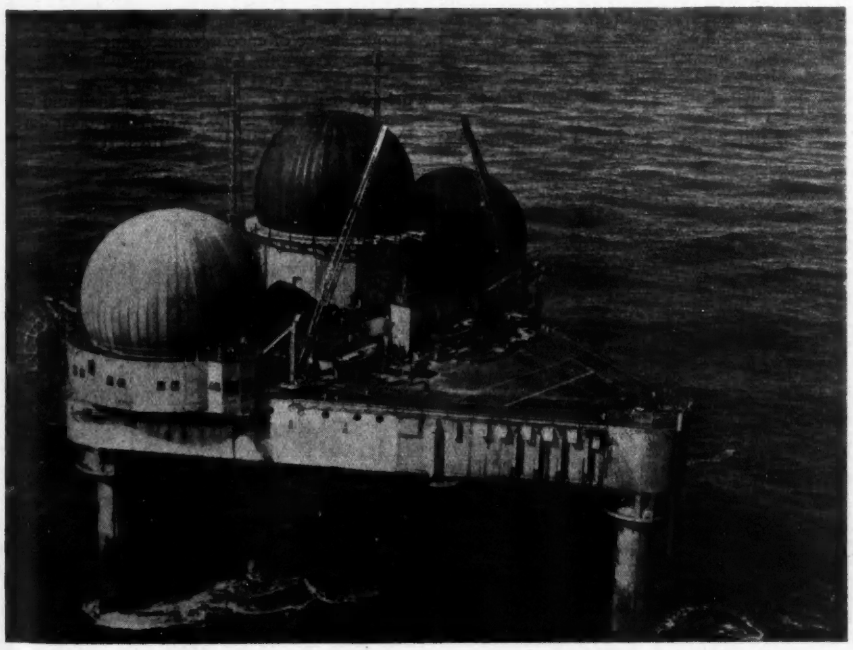


Fig. 1—"Texas Tower No. 2," U.S. Air Force radar station on Georges Bank in the Atlantic Ocean

The general structural design of the platform is shown in Fig. 2. It will be seen that there is a bay formed between the exterior structural girders and the next interior members, which houses the living quarters on the upper deck and the motor generator rooms, boiler-rooms, fuel and water tanks on the lower deck. As constructed on the shipways, a camber was built into the structure, making it 2in higher in the middle, so that, when supported on its caissons, the decks would be virtually level between points of support. At each corner, the 10ft diameter caissons extend through 15ft wells in the platform, and the moment connection is provided by vertical web plates set in the annular space and fitted and welded in place at the site using low-hydrogen welding rod. The use of this connection between the structure and the caissons at their upper ends, together with the established embedment of 48ft into the hard sand bottom at their lower ends, eliminated the need for the diagonal bracing originally contemplated.

The permanent caissons are coated on their lower ends and have "Monel" cladding in the splash zone. To protect these areas from

abrasion while the caissons were passing through the wells in the platform, guide bars were attached to the caissons and further control was provided by heavy pins set in the caisson well extensions and also at the upper deck level. These pins could be adjusted by jacking to guide and control the caissons during sinking. While all the towers will be supported by three permanent caissons, differing water depths and foundation conditions at the various sites call for variations in caisson design. On December 31, 1954, the Bureau of Yards and Docks awarded a contract to the Quincy yard of the Bethlehem Steel Company in Massachusetts for the fabrication of the platform structure, including the permanent caissons, all the permanent equipment, and the interior outfitting. At the same time, the Bureau awarded a separate marine contract jointly to the Raymond Concrete Pile Company

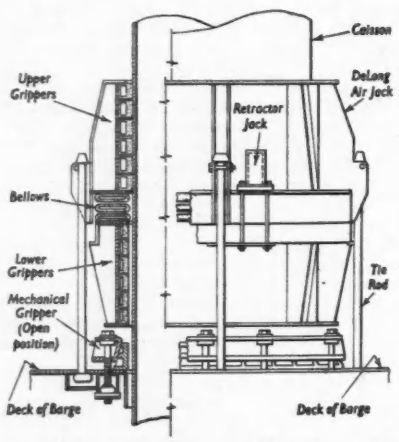


Fig. 3—General arrangement of air jack used in raising the platform on the caissons

and the DeLong Corporation, both of New York, for furnishing the temporary caissons, the special equipment for raising the platform, towing, sinking the caissons, and final outfitting. In general, it was the marine contractor's plan to raise the platform by attaching caisson brackets on each side of the three corners, each bracket carrying two temporary caissons equipped with air jacks. The platform was to be elevated and supported by the temporary caissons until the permanent caissons had been installed and the load of the platform transferred to them. The temporary caissons and their brackets would then be removed.

Construction of Tower

The major questions confronting the contractors were : (1) with the permanent caissons over 180ft long, and the temporary caissons 195ft long, extending 165ft in the air above the deck, what would the towing characteristics be, and how stable would the structure be under varying conditions of wind and wave ? (2) how should the platform be raised 87ft above the sea, and the permanent caissons, weighing over 500 tons apiece, lowered to the ocean bed ? What would be the best procedure for sinking the permanent caissons 48ft below the ocean floor ?

The towing characteristics and stability problems were studied by means of model tests carried out in one of the test tanks at the Stevens Institute of Technology, Hoboken, New Jersey. These tests demonstrated the need for additional buoyancy at the bow or leading corner of the triangular structure. This problem was solved by making the brackets on each side of the bow watertight. The second problem, the raising of the tower, was solved in the following way. In each of the six temporary caisson brackets there were two caissons of 6ft diameter. On each of the temporary caissons there were two air jacks, each of 300-ton capacity, illustrated in Fig. 3. This DeLong air jack consists of three major components : (1) an upper section containing an inflatable rubber gripper enclosed in a steel housing, which is fastened to the caisson bracket with a structural tie beam ; (2) a lower section, also composed of a rubber gripper in a steel housing ; and (3) between these two sections, an expandable and retractable bellows. The action of an air jack resembles that of a boy "shinning" up a tree : the lower gripper is expanded by high-pressure air so as to grip the 6ft caisson ; air pressure in the upper gripper is then relaxed ; and air forces the bellows to expand, pushing the upper gripper and the structure up several inches. The upper gripper is in turn expanded, and the lower gripper deflated and raised an equal amount by the contraction of the bellows. Compressed air is supplied by a battery of compressors, which produce air at over 200 lb per square inch. The air system is arranged so that all jacks can be operated by a central control or any pair of jacks be operated separately.

The permanent caissons are steel cylinders 10ft in diameter and approximately 185ft long. Corrosion protection was provided by "Monel" metal cladding in the splash zone. The lower end was flared out to form a bell 15ft in diameter. An outside steel shell, 15ft in diameter, encircles the lower 63ft of each caisson. Through the annular space thus formed 8in sleeves were set so that jets could be introduced inside the bell, close to the cutting edge. In the same space was installed a system of lubricating jets to permit controlled jetting on the outside of the 15ft cylinder. The annular space between the bell and the outside cylinder was partially filled with concrete before leaving port.

The method used to support the permanent caissons during the tow and to lower them to the ocean bottom was an interesting application of the air jack system. On each side of each permanent caisson a cylinder of 6ft diameter, called a stub caisson, was installed. The stub caissons, each 70ft long, supported a structural frame or bridge which surrounded the permanent caisson and to which the permanent caisson was attached by large steel pins. Each end of the bridge held an air jack, which in turn encircled the stub caissons. Thus, by operating the air jacks up or down on the stub caissons, the permanent caissons could be raised or lowered. The stub caissons were later set inside the permanent caissons and used as forms, and the annular space around them was filled with concrete. The space inside them, 6ft in diameter, was used for salt water and fuel oil intakes.

In the towing position the permanent caissons extended 10ft below the bottom of the platform. From the time each caisson was set in place until the permanent caissons were installed to their final elevation and welded off, the whole operation depended on the continuous functioning of the air jack system. For each of the temporary caissons mechanical grippers were provided, which could have been set in the event of failure of the compressed air system. Because of the deck space required by the permanent caissons and the stub caissons, only the centre section of the deckhouse was completed in the shipyard, and the ends of the deckhouse were left to be completed at sea.

It was not possible to install the temporary brackets on one side of the platform at Quincy, because of the limited clearance of a highway bridge over the Fore River. The platform was towed to East Boston, where the remaining brackets were attached, the temporary caissons installed through these brackets, and the platform raised so as to clear the water by about 35ft. This operation was necessary so that the contractor's cranes could extend the caissons to their full length, and so that the caisson well extensions and monorail crane track could be completed underneath the structure and the permanent caissons extended. Therefore all but 24ft of each caisson was welded into place. The butt welds in the caissons were extremely critical because of the bending moments and were X-rayed to ensure their soundness. Long before sailing time the approximate location of the tower had been determined and soundings made by the Woods Hole Oceanographic Institute. Shortly before departure the area was marked with a buoy set by the U.S. Coast Guard. An Oceanographic vessel, with a representative of the contractor's private weather service, stood by reporting weather conditions until the arrival of the platform.

Towing of Tower

As illustrated in Fig. 4, the structure was towed to sea from Boston astern two 1800 h.p. tow boats. A crew of thirty-five sailed on the platform, including supervisors, various craftsmen and the doctor. The tow took a little less than three days to cover the 160 miles. Weather conditions were ideal. The contractual obligation was to place the platform within 200ft of the marker buoy and to orient it within 5 deg. of a given bearing. With the assistance of a Sperry gyroscopic compass and a skilled operator, and aided by an anchorage system, the temporary caissons were dropped within the desired area and the platform was jacked up well within the required tolerances.

Because of a mishap on the launching ways, Texas Tower No. 2 left East Boston behind schedule with one-third less time to be securely positioned than had been expected. Research into the weather history of this area established August 10 as the earliest recorded date of hurricane storms. Since the bottom deck and the exterior bay on all three sides of the first deck had been sealed up by welding to provide watertight integrity during the tow, the first task was to open up the structure for power, light and heat facilities, and to make these facilities ready for full-scale operation. At the same time the first shipload of additional labour arrived, including personnel to make borings. The selected site was not close enough to the area checked by borings in the summer of 1954 to take a chance of encountering changed soil conditions. Promptly after landing the permanent caissons on the bottom, stone was placed between the 10ft caisson and the 15ft outer shell and was concreted by the method which has been developed and patented by Instrusion-Prepakt,

Fig. 4—Platform structure commencing its seaward tow from Boston with caissons extending 165ft above and 10ft below deck

Incorporated, of Cleveland, Ohio. All subsequent concreting was done by this method, using salt water. However, fresh water was used where the concrete was classified as structural concrete. As shown in Fig. 5, the platform was then jacked up to 81ft above sea level. Since it was situated in 56ft of water instead of 50ft as expected, the height of 81ft was established instead of 87ft.

Completion of Tower

The next major undertaking was to sink and concrete the permanent caissons since delay or failure in these operations, with the hurricane season approaching, could have wrecked the project. It was realised early in the planning stage that the rapid sinking of the caissons was vital to success. It was concluded that to depend on one scheme alone was not prudent. Consequently two methods and the equipment for them were planned. A very powerful jet which could be rotated around the inside of the caisson, together with a vertical dredger pump, was chosen as one method, and heavy-duty clamshell buckets with cutting jets were provided as the other method. The excavation by clamshell bucket, together with a downward force supplied by the air jacks, proved to be the more efficient method. August 10th —the beginning of the hurricane season—arrived with the caissons in various stages of sinking, but none concreted, and the tower was in the direct path of possible storms. The first swells from hurricane "Connie" began to build up. Fortunately, "Connie" swerved inland. By the end of August the caissons were secured by welding, the lower ends concreted, and Texas Tower No. 2 was safe. When the load of the tower had been transferred to the permanent caissons the temporary caissons became more of a menace than a help, since the wave forces against them were transmitted to the tower. To remove them expeditiously the temporary brackets were first burned free from the tower, then jacked down by the air jacks to a predetermined elevation. The air jacks were then removed, the upper end of the caissons made watertight, and each bracket with its two ciassons was allowed to fall into the sea and then towed ashore.

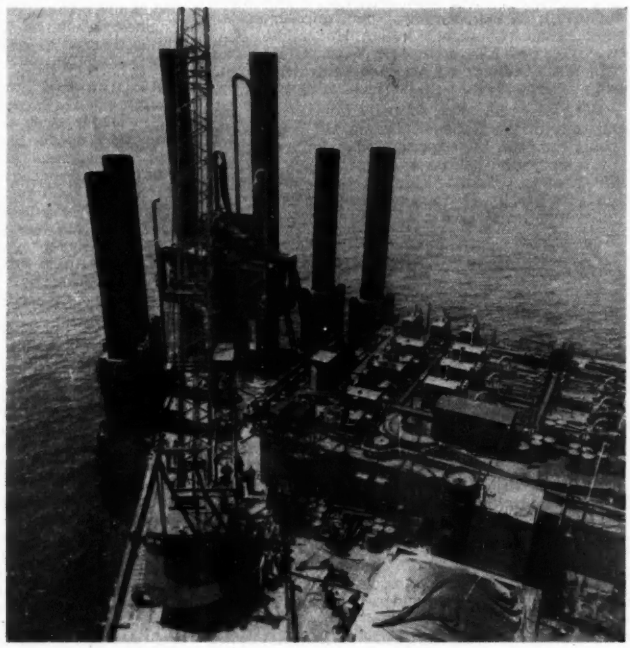


Fig. 5—Platform during erection, with various air jacks in operation on the caissons, showing the air compressor battery

The project called for the use of two ocean-going tow boats and two barges 200ft long. The charter of other vessels was necessary for short periods. The barges were equipped with large mooring engines and quarters for a small crew. One of the tow boats was altered to carry up to forty men. "Walkie-talkies" for conversation between barges, tow boats and the tower were used, while ship-to-shore radio telephones were provided for all vessels and the tower. It required a complicated mooring system with heavy anchors and long anchor lines to moor a barge close enough to the tower so that the cranes could reach the cargoes.

The erection and outfitting of the deckhouse ends and erection of the centre arctic radome tower were involved undertakings. Included were connections through bulkheads and decks for ducts, piping and wireways; installation of various equipment; thermostatic controls; insulation and painting inside, and painting of the entire outside of the tower. More than twelve mechanical and electrical trades were required for this work. The arctic tower is a bolted structure 28ft high, made up of eight thousand pieces. It was assembled on shore, taken apart in four sections, and reassembled on the platform at sea. With ninety to one hundred men on the tower working two twelve-hour shifts, seven days a week, the feeding and care of the labour force was a vital problem. Prohibition was in force from the time the men left shore. The care of job injuries warranted the presence of a physician on the tower at all times.

As shown in Fig. 1, the installation of Texas Tower No. 2 is now completed. It is a self-sustaining home for seventy officers and men of the U.S. Air Force and is an important contribution to the defence of the United States. As far as is known, it is the largest structure ever installed so high above the sea, so far from land, and under such hazardous wave and current conditions.

The project was directed by Commander J. J. Albers, of the Civil Engineer Corps, U.S. Navy, on behalf of the U.S. Department of Defence. The joint consultants were Moran, Proctor, Mueser and Rutledge, of New York, and Anderson-Nichols, of Boston.

New Site for the U.S. National Bureau of Standards

A tract of approximately 550 acres of land near Gaithersburg, Maryland, has been selected as the new site of the Washington laboratories of the National Bureau of Standards. The move will permit the Bureau to plan new buildings to replace present research facilities which over the past fifty years have become inadequate for current needs. The new site was selected after careful consideration as most suited to the special requirements of the Bureau's scientific and engineering work. The choice was based upon a number of factors, including accessibility by railway and highway as well as topography for certain technical projects. The Congress appropriated funds for site acquisition and preliminary planning early in June, after details about the proposed site had been presented to the House and Senate Appropriations Committees. Plans for the site have been given to the National Capital Planning Commission and to the Regional Planning Council, and it is expected that these groups will work with the Bureau in utilising the land. The General Services Administration will participate in planning and will supervise construction. The transfer of operations to the new site is expected to be completed in about five years.

The Bureau occupied its present site at Connecticut Avenue in Washington in 1903. Since that time its responsibilities have greatly increased, largely as a result of the rapid expansion of technology and the growth of scientific research. Extensive programmes of research and development must now be conducted in the physical sciences and engineering to meet the needs of science and industry for new and improved standards and measurement methods. The new site will enable the Bureau to plan for a more up-to-date plant consistent with its continually increasing responsibilities. Many of the buildings on the present site are temporary in nature, and even the permanent buildings are outmoded from the viewpoint of modern technology. It is expected that the new site will make possible a more modern research operation in structures that can be very efficiently managed. In addition, the new site will provide the benefits of a rural location where scientific programmes can be undertaken without interfering in community life. The rural location will remove the Bureau's work from the variety of mechanical, electrical and atmospheric disturbances present in a city and will reduce the effect of these forces upon precise scientific measurements.

In addition to its Washington laboratories, the Bureau maintains a major research centre at Boulder, Colorado, and twenty widely scattered field stations. The Boulder laboratories are concerned with wireless propagation research, wireless standards, and cryogenic engineering. Most of the field stations are engaged in gathering data on wireless propagation.

Award of Howard N. Potts Medal to Dr. E. H. Land

Dr. Edwin H. Land, chairman of the board of directors, president and director of research of the Polaroid Corporation, Cambridge, Massachusetts, was the recipient of the Howard N. Potts Medal of the Franklin Institute in Philadelphia at its annual Medal Day ceremonies in October. Awarded for distinguished work in the sciences or arts, the Potts Medal is being given to Dr. Land for his "... ingenious development of a practical hand camera and a process to expose and to develop the negative and create a good positive simultaneously, all within approximately a minute." In developing this camera, Dr. Land strove for an essentially dry process that could be performed within a camera as simple to load and use as conventional models. His efforts were also concentrated on the development of a single-step process which would use the conventional, high-speed negative material consisting of light-sensitive silver halide in gelatin, the usual film emulsion. In the camera as conceived and finally built, there is a roll of this film and another roll of non-sensitive white paper placed where, in the usual camera, the exposed film is rolled up. After exposure the film and the white paper meet, and pass together, face to face, between a pair of rollers. Attached to the white paper there are tightly sealed envelopes or "pods" containing jellied reagent; one pod for each picture to be made. As film and paper pass through the rolls, the jellied reagent is squeezed from the pod and spread between them in a thin layer. The reagent develops the negative and, at the same time, through the principle of diffusion transfer, forms a positive image on the white paper. After a minute the sandwich is separated and the finished positive picture removed. The Land camera and process have become widely popular among amateur photographers and in many technical and industrial applications. Estate agents, for example, employ the process extensively for prompt showing of their properties to prospective buyers. Engineers observing the results of a series of experiments through changes in the curve displayed on the face of an oscilloscope now make Land photographs of these curves for immediate analysis during the course of the experiment, and in this way avoid the need for interrupting the test procedure.

Personal and Business

Appointments

MR. F. W. MCLEOD has been appointed a director of George Wimpey and Co., Ltd.

SMITHS AIRCRAFT INSTRUMENTS, Ltd., states that Mr. G. G. Roberts has been appointed director of research.

MR. WALTER LATTMAN and MR. C. F. HERRMEYER have been appointed directors of Massey-Harris-Ferguson, Ltd.

MR. E. R. BROWN, M.I.Mech.E., has been appointed works manager (Horwich), London Midland region of British Railways.

MR. DENNIS RIDER has been appointed director of the Glass Manufacturers' Federation, 19, Portland Place, London, W.1.

MR. W. G. MARTIN has been appointed deputy overseas manager of A. Reyrolle and Co., Ltd., Hebburn, Co. Durham.

MR. R. F. LEVY, Q.C., is to become chairman of the Monopolies Commission, which replaces the Monopolies and Restrictive Practices Commission.

MR. C. E. CHAPMAN and MR. E. J. PHILLIPSON have joined the technical sales staff of Acheson Colloids, Ltd., 18, Pall Mall, London, S.W.1.

MR. G. E. GODFREY, M.I.Mech.E., has joined the board of the Silvertown Rubber Company, Ltd., Herga House, Vincent Square, London, S.W.1.

THE BRITISH TRANSPORT COMMISSION states that Hon. Anthony C. Berry and Mr. P. T. Heady have been appointed members of the Western Area Board.

JOHNSON AND PHILLIPS, Ltd., Charlton, London, S.E.7, states that Mr. P. T. Davies, A.M.I.E.E., has been appointed manager of the switchgear department.

Mr. A. H. SIMPSON has been appointed London sales manager of Clyde Tube Forgings, Ltd., 157, Victoria Street, S.W.1. (Telephone, Tate Gallery 9325.)

MR. A. G. STEWART, chairman and general managing director of Stewarts and Lloyds, Ltd., has been appointed a part-time member of the Iron and Steel Board.

MR. G. S. JACKSON has been appointed engineer superintendent of the Shaw Savill Line, in succession to Mr. R. K. Craig who has retired. Mr. Craig joined Shaw Savill in 1919.

THE BRITISH TRANSPORT COMMISSION states that Mr. L. S. Sherwood has been appointed assistant, area management cost and statistics panel secretariat, at the London headquarters.

THE BRITISH INDIA STEAM NAVIGATION COMPANY, Ltd., has appointed Mr. J. F. Boddy to be Commodore Chief Engineer Officer of its fleet. He succeeds Mr. Harold Byers who has retired.

MR. J. O. BOWLEY has been appointed a director and general manager of A.E.C., Ltd., Southall. Mr. G. D. Robinson, M.I.Mech.E., chief engineer, has been appointed a director.

MR. W. OSCAR HIRST has been appointed chief engineer of the John Bright and Brothers, Ltd., group of mills, including those of the subsidiary company, James Stott, Ltd., Oldham.

THE NATIONAL COAL BOARD has established a reconstruction department in its Scottish division. Mr. H. R. King is the divisional reconstruction director, and Mr. R. A. Moore, production director.

MR. ARNOLD PROUD, works manager of Henley Foundries, Ltd., has been appointed a director of the company, which is a subsidiary of W. T. Henley's Telegraph Works Company, Ltd., 51-53, Hatton Garden, London, E.C.1.

THE BRITISH BROADCASTING CORPORATION has announced the following appointments : Mr. G. K. Drake, engineer-in-charge, Blaen Plwy television and v.h.f. transmitting station ; Mr. B. M. Britton, engineer-in-charge, Sandale television transmitting station.

BAKELITE, Ltd., 12-18, Grosvenor Gardens, London, S.W.1, has announced the following appointments in its moulding material sales department : Mr. B. T. Francis, sales manager; Mr. R. J. Chilvers, chief representative, Midland area, and Mr. H. J. Fussell, chief representative, Southern area.

THE INCANDESCENT HEAT COMPANY Ltd., Smethwick, Birmingham, has made the following appointments : Mr. J. A. Swain, chief engineer of the "Equiverse" sales division ; Mr. H. C. Newman, manager of the general sales division, and Mr. G. C. A. Smith, manager of the export division.

AIR MARSHAL SIR CLAUDE PELLY has been appointed controller of aircraft at the Ministry of Supply, in succession to Air Chief Marshal Sir John Baker who is retiring. Other appointments announced by the Ministry of Supply are : Dr. R. Cockburn, controller of guided weapons and electronics ; Rear-Admiral A. S. Bolt, deputy controller of aircraft.

SUDAN LIGHT AND POWER COMPANY, Ltd., announces the following appointments : Mr. F. S. Batty, M.I.Mech.E., M.I.E.E., deputy general manager ; Mr. B. J. Richard, M.I.E.E., chief technical officer ; Mr. J. F. Barlow, electrical engineer, and Mr. J. W. Thompson, assistant electrical engineer.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION states that Mr. H. E. Steel, M.I.N.A., is to retire in January from the position of chief ship surveyor in the consultative branch. Mr. S. A. Hodges, M.I.N.A., is to succeed him, and Mr. W. J. G. Hawkins, M.I.N.A., will succeed Mr. Hodges as deputy chief ship surveyor.

MR. W. L. BECKETT, formerly London area sales manager of the National Gas and Oil Engine Company, Ltd., has been appointed London manager of the company and a director of its subsidiary, National Oil Engines (Export), Ltd. In these positions he succeeds Mr. F. D. Langley who has retired after thirty-four years' service.

Business Announcements

Q.V.F., Ltd., has acquired new premises at Duke Street, Fenton, Stoke-on-Trent.

HOLDEN AND BROOKE, Ltd., Sirius Works, Manchester, has opened a branch office at 9, Broad Quay, Bristol (telephone, Bristol 28581).

W. T. HENLEY'S TELEGRAPH WORKS, Ltd., states that the title of Oakley Brothers, Ltd., has been changed to Henley Foundries, Ltd.

MILLSPAUGH, Ltd., Sheffield, states that Mr. H. Humphries, deputy chairman, and Mr. W. Jenkins Gibson, are visiting Canada and the U.S.A.

MR. R. W. TAYLOR, M.I.C.E., engineer-in-chief to the Crown Agents for Oversea Governments and Administrations, is making an official visit to Nigeria.

REMINGTON RAND, Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1, has formed an electronics division under the control of Mr. C. W. Elliott.

Mr. HERBERT BRIDGE (British Moulded Plastics, Ltd.), Mr. J. Lesser (Crystalate, Ltd.), and Mr. R. Sternberg (Sterling Moulded Materials, Ltd.), are on a visit to the U.S.S.R.

WICKMAN, Ltd., Banner Lane, Coventry, has separated the export departments of its machine tool and "Wimet" divisions. Mr. Ernest Thompson has been appointed export manager of the "Wimet" division.

VICKERS-ARMSTRONGS (AIRCRAFT), Ltd., has set up a military aircraft office at Weybridge. Mr. Jeffrey Quill has charge of the office, assisted by Group Captain R. J. Carvell and Mr. M. Scott Mackirdy.

Contracts

W. J. FRASER AND CO., Ltd., Harold Hill, Romford, Essex, has been awarded a contract, worth approximately £750,000, for the complete installation of new nickel refining plant at Clydach, South Wales, for Mond Nickel Company, Ltd. Besides the design, manufacture and installation of the actual plant, the contract includes complete site clearance and the erection of a factory building.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., and BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., have received orders from the British Transport Co nmission for the design, supply and installation of overhead conductor equipment for the 25kV, single phase, 50 c/s railway electrification schemes between Manchester and Crewe (220 track miles) and Colchester and Clacton (50 track miles). The former scheme represents the first stage of the complete electrification between London (Euston), Crewe, Manchester and Liverpool, for which it will serve as a pilot project ; preliminary work has already begun.

Miscellanea

PORTABLE SPRAY PAINTING PLANT.—A new light weight petrol-engined portable spray painting plant being made by Alfred Bullows and Sons, Ltd., Walsall, consists of the firm's small "Hydrovane" compressor powered by a 75 c.c. single-cylinder, two-stroke, petrol engine with one lever control for starting, running and stopping. This equipment, which weighs only 46 lb, is supplied with a spray gun with a quart container, air hose and connectors, and it will operate with a range of pressure containers.

DIESEL ENGINEERS AND USERS ASSOCIATION.—At a general meeting of the Diesel Engineers and Users Association held on October 18th, Mr. J. R. P. Smith read a paper entitled "The Use of Internal Combustion Plant for Peak Loads in Electricity Supply Systems." The paper, after briefly relating the historical background, discusses the peaks in the system-load curves, examples of which are illustrated graphically. There is an appreciation of the techniques of system-operation and a review of some of the economic aspects of diesel generation, followed by a study of the efficient operation of diesel stations, including a breakdown of costs of a particular station. Engineering matters such as loading and liner wear are examined, together with the question of the choice of fuel.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—On October 23rd, Professor A. M. Robb, D.Sc., read a paper with the title "Some Aspects of Ship and Propeller Experiments," before the Institution of Engineers and Shipbuilders in Scotland. The paper considers in detail two problems in the correlation of ship and model performance and re-examines the series of experiments in which models of varying scale were used. Plots of published results show that discrepancies have not been satisfactorily explained. In a similar manner suitable plotting of the "Lochnevis," "Clairton" and "Tervacte" propeller records indicates that discrepancies exist in the expansion of model propeller results and it is suggested that there is a scale effect between model and full-size propeller for which no allowance is at present customary.

WET BELT GRINDER.—A new wet belt grinder designed for use with electro-coated, resin bonded abrasive belts has been introduced by Taylor Tools and Supplies, Ltd., Broadheath, Altrincham, Cheshire. It works with belts up to 9in wide and 108in long, and belt speeds from 2500ft to 5500ft per minute can be selected to meet particular requirements. The grinder has a hand-operated 12in by 11in table fitted with a micrometer stop for repetition setting purposes ; if required this table can be replaced by automatic work fixtures. The belt pulleys are carried in ball and roller bearings and are driven through vee belts by a motor mounted on a hinged baseplate which can be adjusted for tensioning purposes. The base of the machine forms a large settling tank for the coolant and a drawer is fitted to collect the heavy swarf before it reaches the tank. Coolant is fed by a pump to jets at a point above the work, to the back of the abrasive belt to lubricate it on its path over the platen, and to a jet below the work table which flushes the swarf off the belt.

ASSOCIATION OF ENGINEERING DISTRIBUTORS.—The annual luncheon of the Association of Engineering Distributors, Ltd., was held in London on Tuesday, October 23rd. In proposing the toast of the Association, Mr. F. J. Erroll, the Parliamentary Secretary to the Ministry of Supply, spoke of scientific development in recent times. He pointed out that the developments made in such things as electronic devices were in a large measure due to the skill of the craftsman in making possible their manufacture, and that industry would always be dependent upon the skilled tradesman and precision in mechanical engineering. Mr. A. N. Wiggett, the president of the association, spoke of its work and service to industry. The members of the association, he said, would welcome closer co-operation with such manufacturers who would be prepared to assist in the training of distributors' staffs. If qualified trained men from manufacturers' works could give technical instruction to those responsible for the distribution of their products it would be beneficial to makers, distributors and customers alike.

RESEARCH SCHOLARSHIPS.—The British Broadcasting Corporation is presenting one or two research scholarships each year, valued at £385 per annum, to university graduates in electrical engineering or physics who obtain good honours degrees, to give them the opportunity to work for a higher degree at any university in the United Kingdom, not necessarily at the one where they graduated. The scholarships are for two years in the first instance with the possibility of extension in suitable cases, if necessary. The scholarships are limited to male British subjects normally resident in the United Kingdom. The only condition applying to the subject for research is that it must be in those fields of telecommunications or physics which have an application to sound or television broadcasting. The Corporation has given one research scholarship only this year and that was to Mr. P. C. J. Hill, who graduated at Birmingham University with first class honours in electrical engineering. Mr. Hill will conduct his researches in the Department of Electrical Engineering at the Imperial College of Science and Technology.

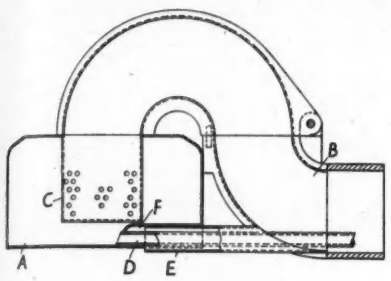
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

BURNERS AND SPRAYERS

758,275. March 10, 1954.—OIL BURNERS, Nu-Way Heating Plants, Ltd., Vines Lane, Droitwich. (*Inventor: William James Osborne Bartlett.*)

The invention relates to oil burners for heating boilers or like purposes, comprising a basin-like oil receptacle to which the oil is supplied by a pipe. Its object is to enable the clogging of the oil pipe as a consequence of carbonisation of the oil in the pipe to be obviated or minimised in a simple and reliable manner. As will be seen from the drawing,



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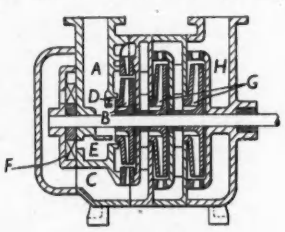
a burner comprises an oil receptacle *A* of cylindrical, basin-like shape. This receptacle is formed on or secured to an air duct *B* supplied by a blower. The discharge end of the air duct is in the form of an inverted "U," and the part which depends into the receptacle terminates in a perforated nozzle *C* through which the air to support combustion can enter the receptacle *A* laterally at a position adjacent to the normal oil level. The oil is supplied to the receptacle through a pipe *D* and, according to the invention, that part of the pipe which would otherwise be excessively heated is surrounded by an air by-pass pipe *E* which at one end is connected to the air duct *B* and which at the other end terminates immediately adjacent to the discharge end of the oil pipe *D*, this end of the air duct being open to the exterior of the receptacle *A*. In one convenient arrangement a radial recess *F* is formed in the base of the receptacle and extended over about one-half of the base. The discharge end of the oil pipe *D* is secured to the closed end of the recess and a part of the oil pipe and air by-pass pipe *E* lies within the recess. The by-pass pipe forms an air jacket through which a continuous stream of air can flow from the air duct *B* and around the oil pipe *E*. The cooling effect of this stream protects the oil pipe against excessive heating and risk of carbonisation of the oil in the oil pipe and consequent blocking of the pipe is thus avoided or minimised.—*October* 3, 1956.

PUMPS

758,519. May 7, 1953.—MULTI-STAGE SELF-PRIMING CENTRIFUGAL PUMP, Otto Siemen, Lessingstrasse 26, Itzehoe/Holstein, Germany, and Johannes Hinsch, Schillerstrasse 27, Itzehoe/Holstein, Germany.

The invention relates to multi-stage self-priming centrifugal pumps in which a partial admission suction stage is combined with full admission centrifugal stages. The drawing shows a form of construction in which extraction is effected directly before the suction eye of the first centrifugal stage. The



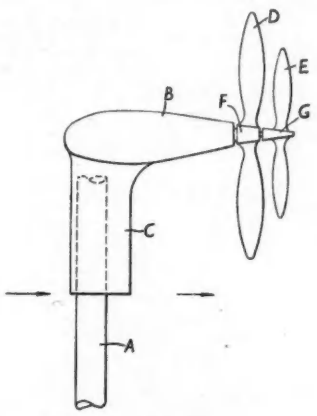
No. 758,519

liquid is pumped from the suction chamber *A* of the pump, through the impeller *B* into the chamber *C*. The annular channel *D* situated before the entrance to the impeller *B* is open towards the suction eye and is connected through the chamber *E* with the suction sector of the priming stage *F*. The gases are thus extracted by this arrangement before the suction eye of the first centrifugal stage. The first centrifugal stage and the priming stage work in parallel and pump jointly into the chamber *C*. From here the liquid is pumped into the next centrifugal stages *G* and from there into the pressure chamber *H* of the pump. The gases may be led from the chamber *C* either outwards or to a suitable point behind the first impeller *B*. The specification also shows three further modified forms of construction according to the patent.—*October* 3, 1956.

WIND POWER PLANTS

758,628. December 23, 1954.—A WIND-POWER INSTALLATION, Rudolf Arnold Erren, Wunstorfer Strasse 88 (20a), Hannover-Limmer, Germany.

The invention relates to a wind power installation, comprising a generator enclosed in a stream-lined housing mounted so as to be free to turn at the top of a support, the generator automatically adjusting itself to the direction of the wind. The drawing shows an elevation of a propeller and a transverse section of the propeller mast. *A* is the upper end of a carrying mast in the form of a simple tube. *B* is the generator housing which is streamlined and



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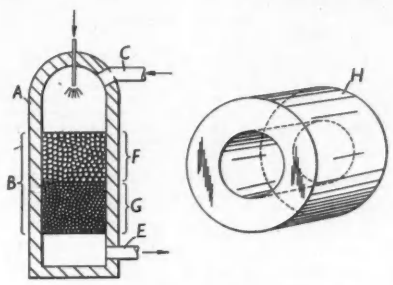
mounted to pivot on the tube by means of a socket extension *C*. The external surface of the projection *C* is streamlined in shape, the axis of this streamlined member being parallel with the axis of the generator housing *B*. The generator housing is so disposed relative to the carrying mast that the aerodynamically shaped leading surface projects only a little beyond the streamlined boss *C*. The tapering end of the generator housing, which is of constantly diminishing cross-section, is arranged so that it projects a relatively long way beyond the carrying mast. In this arrangement the generator is assumed to have its armature and exciter system rotating in opposite directions. The concentric shafts of the two systems are coaxial and project from the centre of the small, flat tail face of the housing. On both shafts propellers *D* or *E* are mounted in bosses *F* and *G*, which form a continuation of the streamlined housing *B*. The propeller adjacent the mast is of appreciably greater diameter than the outer propeller. Under the influence of the wind, the generator adjusts itself automatically in such manner that its longitudinal axis lies in the direction of the wind. By reason of the relatively large distance between the propeller *D* and the carrying mast *A*, and favoured by the streamlined boss *C*, the wind meets the surface of the propeller *D* in completely rectilinear flow. It acts upon the front side of the propeller by pressure, and by suction in that annular surface by which the large propeller extends beyond the smaller propeller. The suction force is effective in the main upon the smaller propeller *E*. The diameters of the two propellers are such that, given the same wind velocity, both rotate at the same, or approximately the same, speed.—*October* 3, 1956.

GAS PRODUCTION PLANTS

758,548. March 8, 1954.—PRODUCTION OF COMBUSTIBLE GASES, The South Eastern Gas Board, Katherine Street, Croydon, Surrey, and The Power-Gas Corporation, Ltd., Stockton-on-Tees, County Durham.

The invention relates to the production of combustible gases from hydrocarbons by a high temperature catalytic process in which a mixture of hydrocarbons in vapour form and steam is passed through a bed of a catalyst which actively promotes the reaction between hydrocarbons and steam, resulting in the formation of carbon monoxide and hydrogen to produce a gas suitable for use as town gas, either alone or when mixed with coal gas. Suitable catalyst materials are described in Specifications Nos. 648,965 and 666,524, and another suitable catalyst material is a mixture of magnesite and calcium oxide. The bed of catalyst illustrated in the drawing is for use in the production of town gas by a process in which hydrocarbons in vapour form are passed through the heated catalyst bed in conjunction with steam. The reaction is carried out in a catalyst chamber *A*, which is lined with refractory material and contains in its central zone a bed of catalyst *B*. In operation, when the catalyst bed is at a sufficiently high temperature, steam, preferably preheated, is introduced into the chamber *A* through a steam inlet *C* and hydrocarbons through an inlet above. In view of the high temperature in the catalyst chamber the hydrocarbons vaporise and pass through the catalyst bed *B* with the steam. During their passage through the bed the hydrocarbons react with the steam to produce a



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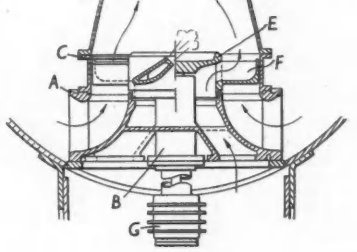
combustible gas, which emerges through an outlet *E*. During the period which the steam and hydrocarbons are flowing through the catalyst bed, heat is absorbed from the bed because the reaction is endothermic. When the catalyst bed has been cooled to the extent that the reaction can no longer take place satisfactorily, the flow of steam and hydrocarbons is cut off and the "blow" period commences. The "blow" is performed by blowing air, preferably preheated, or hot furnace gas containing excess oxygen, upwardly through the catalyst bed. The catalyst bed is formed of two parts *F* and *G* having larger and smaller heat capacities. A typical catalyst body *H* is shown on the right of the drawing. This consists of a short, hollow, thick-walled cylinder made of a suitable catalyst material such as a mixture of bauxite and calcium oxide or a mixture of magnesite and calcium oxide. Such catalyst bodies can be formed easily in large quantities by extrusion through a die.—*October* 3, 1956.

STEAM GENERATORS

758,609. September 13, 1954.—INDUCED DRAUGHT INSTALLATIONS FOR BOILERS, Henschel and Sohn Gesellschaft mit beschränkter Haftung, 2, Henschelstrasse, Kassel, Germany.

The invention relates to induced draught installations for steam boilers, more particularly for locomotive boilers. In the drawing, *A* is a suction housing having a bearing body *B* for mounting the fan wheel. *C* is a fan wheel housing attached at one side to the suction housing and on the other to a diffuser chim-



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ney *D*. Only the lower part of the chimney is shown in the drawing so that the diffuser is not visible. *E* is a combined hollow fan and driving turbine wheel with hollow blades *F*, and *G* is a lubricating-oil circulating pump for the bearings within the bearing body *B*. In operation, steam led from the boiler into the hollow fan wheel flows out through the nozzle-like apertures in the fan wheel blade edges, setting the fan wheel into rotation, which thus sucks the boiler flue gases into the chimney. The waste steam flows off through the chimney and exerts an additional suction effect in the flue gases already sucked in by the fan.—*October* 3, 1956.

Catalogues and Brochures

A. REYROLLE AND CO., Ltd., Hebburn, County Durham.—A catalogue describing many types of plugs and sockets.

EDGAR VAUGHAN AND CO., Ltd., Birmingham.—A booklet containing information on cutting oils and lubricants.

PETBOW, Ltd., Sandwich, Kent.—A catalogue of welders' accessories, including protective clothing, goggles and tools.

HIGH DUTY ALLOYS, Ltd., 89, Buckingham Avenue, Trading Estate, Slough, Bucks.—A booklet of Hiduminium technical data.

ENGLISH ELECTRIC COMPANY, Ltd., Stafford.—Publication No. W.A./129. A catalogue of welding equipment and electrodes.

PORTER ELECTRICAL PRODUCTS, Ltd., 2, North Park Road, Harrogate, Yorks.—A leaflet describing the earth-continuity and bonding system.

W. C. HOLMES AND CO., Ltd., P.O. Box No. 37, Turnbridge, Huddersfield.—Brochure No. 62, describing equipment produced, ranging from small industrial air blowers to the design, manufacture and installation of complete by-product recovery and electrical precipitation plant.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 2nd.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "Modern Railway Signalling," J. Sulston, 7.30 p.m.

Mon., Nov. 5th.—LEEDS BRANCH: Great Northern Hotel, Leeds, A.S.E.E. Exhibition Film, 1956, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, Discussion on "13th Edition I.E.E. Regulations," E. J. Sutton, 7.30 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, Visit of Executive Council Member, 7.30 p.m.

Tues., Nov. 6th.—LUTON BRANCH: Chamber of Commerce, George Street, West Luton, "Automatic Relays and Controls," W. L. Stern, 8 p.m.——OXFORD, READING AND DISTRICTS BRANCH: The University, London Road, Reading, "Electronic Measuring Instruments," R. Postle, 7.15 p.m.——TYNESIDE BRANCH: Crown Hotel, Newcastle upon Tyne, "Power Factor," 7.30 p.m.——W. LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, "The Housewives' Anticipation of Appliances for the Home in Ten Years' Time," Miss M. E. Bailey, A.S.E.E. Exhibition Film, 1956, 7.30 p.m.

Wed., Nov. 7th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Electricity in the Newspaper World," 7.30 p.m.——N. LONDON BRANCH: Queen's Head, 677, Green Lanes, Harringay, N.4, "Fluorescent Lighting Circuits and Servicing of Fluorescent Fittings," G. V. McNeill, 7.45 p.m.——PRESTON BRANCH: R.A.F.A. Club, East View, Preston, "Brains Trust," 7.30 p.m.

Thurs., Nov. 8th.—PORTSMOUTH BRANCH: Royal Beach Hotel, Southsea, "Running and Maintenance Costs of Various Types of Lighting," J. F. Roper, 8 p.m.——S.W. LONDON BRANCH: Prince of Wales Hotel, S.W.19, "Reactor Control Philosophy," D. D. Bowen, 7.30 p.m.

Fri., Nov. 9th.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, Stoke, "Fluorescent Lighting," C. B. Styles, 7.30 p.m.

BELFAST ASSOCIATION OF ENGINEERS

Wed., Nov. 14th.—College of Technology, Belfast, "Nuclear Power Stations," G. F. Kennedy, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Nov. 7th.—MERSEYSIDE SECTION: Council Room, Chamber of Commerce, 1, Old Hall Street, Liverpool, 3, "Industrial Television," J. E. H. Brace and R. Swinden, 7 p.m.

Thurs., Nov. 8th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Oscilloscope for Engine Testing," R. K. Vinycomb, 7 p.m.

Wed., Nov. 14th.—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "The Automatic Factory," J. A. Sargrove, 7.15 p.m.——N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "Some Practical Aspects of Echo Sounding," A. M. Sutton, 6 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Nov. 3rd.—Caxton Hall, Caxton Street, London, S.W.1, "The Atmosphere of Mars," R. M. Goody, 6 p.m.

COVENTRY ENGINEERING SOCIETY

Thurs., Nov. 8th.—Victor Social Club, Coventry, Film "Automation in Production," 7.30 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Nov. 6th.—Church Institute, Hull, Film "Road Safety," 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., Nov. 7th.—EDINBURGH CENTRE: Y.M.C.A., 14, South St. Andrew Street, Edinburgh, "Design Today," A. Maynard, 6.15 p.m.——NEWCASTLE UPON TYNE CENTRE: Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, 1, "Television Studio Lighting Equipment," K. R. Ackerman, 6.15 p.m.——SWANSEA GROUP: S. Wales Electricity Board, The Kingsway, Swansea, "Lighting in Buildings—Training and Practice," Derek Phillips, 6.30 p.m.

Thurs., Nov. 8th.—CARDIFF CENTRE: S. Wales Electricity Board, The Hayes, Cardiff, "The Use of Coloured Light," H. Hewitt and C. R. Passmore, 7 p.m.

Mon., Nov. 12th.—SHEFFIELD CENTRE: Medical Library, The University, Western Bank, Sheffield, 10, "Trends in Interior Installations and Design," H. H. Ballin, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Nov 2nd.—PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "The Development of the B.R.M.," 7.30 p.m.

Tues., Nov. 6th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "The Use of Radio Isotopes in Industry," C. W. Jones, 7 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "Choice of Pumps," 7 p.m.

Wed., Nov. 7th.—LEICESTER BRANCH: Bell Hotel, Leicester, "Process Steam," L. G. Northcroft, 6.30 p.m.——SOUTHERN BRANCH: Carnegie Library, Fratton Road, Portsmouth, "Noise," E. J. Richards, 7.30 p.m.

Thurs., Nov. 8th.—GLASGOW BRANCH: Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, "An Introduction to Atomic Energy," J. A. Dixon, 7.15 p.m.——MERSEYSIDE AND N. WALES BRANCH: Exchange Hotel, Liverpool, "Industrial Refrigeration," L. Perrin, 7.15 p.m.——N.E. BRANCH: Roadway House, Orsford Street, Newcastle upon Tyne, "Engineering Economics," T. S. Welch, 7 p.m.

Mon., Nov. 12th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "The Maintenance of Gas Turbine Aircraft Engines in the Royal Air Force," D. J. Hughes, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Mon., Nov. 5th.—LANCASHIRE BRANCH: Midland Hotel, Manchester, "Fast Drying Bonding Materials," A. I. Donaldson, 7 p.m.——SHEFFIELD BRANCH: College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, 1, "Training," O. W. Reynolds; "Foundry Training," H. Parkin, 7 p.m.

Tues., Nov. 6th.—SLOUGH SECTION: High Duty Alloys, Ltd., Slough, "Gases in Metals," C. E. Ransley, 7.30 p.m.

Thurs., Nov. 8th.—BEDS. AND HERTS. SECTION: Town Hall, Luton, "Mechanising a Small Jobbing Foundry," R. H. Blandy, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Nov. 5th.—STUDENT MEETING: 85, Minories, London, E.C.3, Films, including "Mail Boat," 6.30 p.m.——MERSEYSIDE AND N.W. SECTION: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Some Recent Metallurgical Problems in Marine Engineering," B. Todd, 6.30 p.m.

Tues., Nov. 6th.—JUNIOR LECTURE: East Ham Technical College, London, E.6, "Modern Marine Steam Turbines," J. H. Gooch, 7.30 p.m.

Wed., Nov. 7th.—JUNIOR LECTURE: Technical College, Acton, "Launching of Ships," R. S. Hogg, 7 p.m.

Thurs., Nov. 8th.—N.E. COAST SECTION: Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, "The Selectable Superheat Boiler," R. E. Zoller, 6.15 p.m.

Mon., Nov. 12th.—MERSEYSIDE AND N.W. SECTION: Old Swan Technical College, Liverpool, "Petroleum Refining," E. H. Wild, 7.30 p.m.

INSTITUTE OF METALS

Tues., Nov. 6th.—OXFORD LOCAL SECTION: Cadence Café, Cornmarket Street, Oxford, "Radiation Damage," A. T. Churchman, 7 p.m.

Thurs., Nov. 8th.—BIRMINGHAM LOCAL SECTION: Exchange and Engineering Centre, Stephenson Place, Birmingham, "The Metallurgy of Steel for Deep Drawing and Pressing," A. J. K. Honeyman, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Nov. 7th.—26, Portland Place, London, W.1, Symposium on "Digital Computers in the Petroleum Industry," 5.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Nov. 12th.—NORTHERN CENTRE: N.E. Electricity Board's Lecture Theatre, Carliol House, Newcastle, "The Design of Agricultural Tyres and other Uses of Rubber in Agriculture," B. W. D. Lacey, 6.45 p.m.——WESTERN CENTRE: Electricity House, Bristol, "The Economics of Rural Electrification," W. J. Guscott, "Electric Motors on the Farm," B. Stocks, 7.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Nov. 7th.—Royal Institution, Albemarle Street, London, W.1, Symposium on Grinding, 3 p.m. to 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 6th.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, Presidential Address, H. J. F. Gourley, 5.30 p.m.——YORKSHIRE ASSOCIATION: C.E.A., 1, Whitehall Road, Leeds, "High Water Power—The Development of the North of Scotland Hydro-Electric Board," T. Lawrie, 6 p.m.

Thurs., Nov. 8th.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Birmingham, "Aspects of Traffic in America," N. P. Brand, 6 p.m.

Tues., Nov. 13th.—PUBLIC HEALTH MEETING: Great George Street, Westminster, London, S.W.1, "The Effect of Synthetic Detergents on the Biological Oxidation of Sewage," L. Barden and P. C. G. Isaac, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 5th.—S. MIDLANDS CENTRE: James Watt Memorial Institute, Birmingham, "The Potentialities of Railway Electrification at Standard Frequency," E. L. E. Wheatcroft and H. H. C. Barton, 6 p.m.

Tues., Nov. 6th.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "Electric Strength of Highly Compressed Gases," E. H. Holt; "Insulated Properties of Compressed Electro-Negative Gases," P. R. Howard, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Tridac—A Large Analogue Computing Machine," F. R. J. Spearman, J. J. Gait, A. V. Hemingway and R. W. Hynes, 7 p.m.

Wed., Nov. 7th.—N. SCOTLAND SUB-CENTRE: Caledonian Hotel, Aberdeen, Inauguration of Sub-Centre Chairman and Address, 7.30 p.m.——S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Tridac—A Large Analogue Computing Machine," F. R. J. Spearman, J. J. Gait, A. V. Hemingway and R. W. Hynes, 7 p.m.

Thurs., Nov. 8th.—ORDINARY MEETING: Savoy Place, London, W.C.2, Lecture on the Visit of the British Electricity Supply Delegation to the Soviet Union, J. Eccles, 5.30 p.m.——N. SCOTLAND SUB-CENTRE: Queen's College, Dundee, Inauguration of Sub-Centre Chairman and Address, 7 p.m.

Mon., Nov. 12th.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Power Factor in Industrial Installations," opened by C. F. Freeman, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Nov. 5th.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, 6, "The Design and Application of Centrifugal Pumps," D. W. Coleman, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 6th.—39, Elmbank Crescent, Glasgow, "The Operation of an Oil Refinery," J. G. Annan, 6.30 p.m.

Wed., Nov. 7th.—JOINT MEETING WITH DUNDEE INSTITUTE OF ENGINEERS: Queen's College, Dundee, "Industrial Organisation," P. Hanika, 7.15 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Mon., Nov. 5th.—N.E. COAST BRANCH: Institute of Mining and Mechanical Engineers, Neville Street, Newcastle upon Tyne, 1, "Oil Burning," T. Marsden, 6.30 p.m.

Wed., Nov. 7th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Heating and Hot Water Supply and Demand in Flats," K. W. Dale, 6 p.m.——E. MIDLAND BRANCH: College of Technology, Leicester, "Water Treatment for the Heating Engineer," F. R. Jarrett, 6.45 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Nov. 2nd.—N.E. BRANCH: King's College, Newcastle upon Tyne, "Modern Vehicle-Actuated Road Signals," F. V. Webster, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 2nd.—GENERAL MEETING IN CONJUNCTION WITH THE INTERNAL COMBUSTION ENGINE GROUP: "A Review of the Performance of Exhaust Systems for Gas Turbine Aero-Engines," P. F. Ashwood, 6 p.m.——SCOTTISH BRANCH: Robert Gordon's College, Aberdeen, "Nuclear Pressurised Water Reactors," J. M. Kay and F. J. Hutchinson, 7.30 p.m.

Mon., Nov. 5th.—N.E. BRANCH JOINT MEETING WITH THE INSTITUTIONS OF CIVIL AND ELECTRICAL ENGINEERS: Literary and Philosophical Society, Westgate Road, Newcastle upon Tyne, "Nuclear Reactors for Power Production," B. L. Goodlet, 6 p.m.

Wed., Nov. 7th.—SOUTHERN BRANCH: R.A.E. Technical College, Farnborough, Hants, "Some Engineering Problems of High-Speed Flight," R. F. Creasey, 7.30 p.m.——YORKSHIRE GRADUATES' SECTION: Visit to Jaguar Cars, Ltd., Coventry, 2 p.m.

Thurs., Nov. 8th.—LUBRICATION GROUP AND EDUCATION GROUP DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "The Extent to which Lubrication Should Enter into First Degree and H.N.C. Courses," 6.45 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "A Criticism of the Technical Education of Recently Qualified Engineers," P. P. Love, 6.45 p.m.——YORKSHIRE BRANCH: White Swan Hotel, Halifax, "Experiments on the Deflexions and Vibrations of Drilling Machines," D. F. Galloway, 7 p.m.

Fri., Nov. 9th.—GENERAL MEETING IN CONJUNCTION WITH THE HYDRAULICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Rotating-Beam Channel and 30in Water Tunnel at the Admiralty Research Laboratory," E. H. Lever, H. Ritter, M. Woolfson and C. T. Wright, 6 p.m.

Tues., Nov. 13th.—AUTOMOBILE DIVISION GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Papers on Research in Automobile Stability and Control, authors from the Cornell Laboratory, United States of America, (1) "General Introduction to a Programme of Dynamic Research" William F. Milliken, jun., and David W. Whitcomb, (2) "Theoretical Prediction and Experimental Substantiation of the Response of the Automobile to Steering Control," Leonard Segel, (3) "A Device for Measuring Mechanical Characteristics of Tyres on the Road," William Close and Clifford L. Muzzey, (4) "Tyre Tests and Interpretation of Experimental Data," Albert G. Fonda, (5) "Design Implications of a General Theory of Automobile Stability and Control," David W. Whitcomb and William F. Milliken, jun., 4.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Nov. 15th.—Geological Society, Burlington House, Piccadilly, London, W.1, "A New Process for Pneumatic Stowing: Its Development and Introduction at the Rio Tinto Mines, Spain," Edward Rich, "Some Developments in Tailing Disposal at Roan Antelope Copper Mines, Northern Rhodesia," M. R. Goldick, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Nov. 7th.—S. ESSEX SECTION: Ilford Club, 21a, Balfour Road, Ilford, "New Metals—With Special Reference to Titanium, Zirconium, Molybdenum, &c.," T. W. Farthing, 7.30 p.m.——WOLVERHAMPTON SECTION: County Technical College, Stafford, "Management and Organisation," E. L. G. Robbins, 7.15 p.m.——NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, "Spring Design and and Manufacture," J. A. Roberts, 7 p.m.——LIVERPOOL SECTION: Radiant House, Bold Street, Liverpool, "The Institution and You," J. E. Hill, 7.30 p.m.——PRESTON SECTION: Harris Institute, Corporation Street, Preston, "Special Purpose Unit Head Machines," T. W. Elkington, 7.15 p.m.

Fri., Nov. 9th.—EASTERN COUNTIES SECTION: Diocesan Hall, Tower Street, Ipswich, "Automation—Does it Concern You?" Sir Walter Puckey, 7.30 p.m.——GLOUCESTER SECTION: Technical College, Brunswick Road, Gloucester, "Some Aspects of Protection Processes," R. Gillanders, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 2nd.—W. COUNTIES BRANCH: New Engineering School, University of Bristol, "The Results of Experiments on Torsion in Concrete and Their Application to Design," S. Armstrong, 6 p.m.

Tues., Nov. 6th.—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough, "Binns Store," F. R. Bullen, 6.30 p.m.——NORTHERN IRELAND BRANCH: College of Technology, Belfast, "Gasholder Development and Design," W. R. Garrett, 6.45 p.m.

Wed., Nov. 7th.—NORTHERN COUNTIES BRANCH: Neville Hall, Newcastle, "Binns Store," F. R. Bullen, 6.30 p.m.——WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, "Modern Steelwork Fabrication," G. E. Cooper, 6.30 p.m.

Thurs., Nov. 8th.—11, Upper Belgrave Street, London, S.W.1, "The Elliott Secondary School, Putney," Walter C. Andrews, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 2nd.—FILM EVENING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Man with a Thousand Hands" and "On a New Track," 7 p.m.

Fri., Nov. 9th.—Pepys House, 14, Rochester Row, London, S.W.1, Chairman's Address, "Some Aspects of Repairs to Airframes," J. C. Y. Baker, 7 p.m.

Mon., Nov. 12th.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, "Some Aspects of Industrial Water Treatment," C. W. Drane, 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Nov. 9th.—Engineers' Club, Albert Square, Manchester, "The Design and Development of the 'Deltic' Engine," C. D. Carmichael, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Nov. 2nd.—PARSONS MEMORIAL LECTURE: Literary and Philosophical Society, Newcastle upon Tyne, "A Review of Naval Propulsion Engineering Progress in the Last Ten Years," Sir Frank T. Mason, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Nov. 6th.—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "Methods of Shuttering as They Affect the Design and Surface Finish of Concrete," C. Parry, 6.45 p.m.

Wed., Nov. 7th.—N.W. BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Methods of Shuttering as They Affect the Design and Surface Finish of Concrete," C. Parry, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Nov. 6th.—MAIN LECTURE: Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "London Airport," Sir John D'Albiac, 6 p.m.

Tues., Nov. 13th.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Air Conditioning of Aircraft," E. W. Still, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Nov. 12th.—ORDINARY GENERAL MEETING: 12, Great George Street, London, S.W.1, Presidential Address, W. E. A. Bull, 5.45 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Mon., Nov. 5th.—CORROSION GROUP: Chemistry Lecture Theatre, The University, Leeds, "The Stress Corrosion of Steel in Caustic Soda Solutions," F. A. Champion, 7 p.m.

Thurs., Nov. 8th.—ROAD AND BUILDING MATERIALS GROUP: 14, Belgrave Square, London, S.W.1, "The Use of Mechanical Tests in the Design of Bituminous Road Surfacing Mixtures, Part 2—Stability Tests on Rolled Asphalt," D. C. Broome and A. Please, 6 p.m.

SOCIETY OF ENGINEERS

Mon., Nov. 5th.—ORDINARY MEETING: Geological Society, Burlington House, Piccadilly, London, W.1, "Gas Turbines in Theory and Practice," D. F. Collins, 5.30 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Nov. 15th.—Park Place, Cardiff, "The Northward Attenuation of the Coal Seams in the Swansea District," S. Carey Jones, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Nov. 14th.—LONDON BRANCH: Hope House, 45, Great Peter Street, Westminster, London, S.W.1, "Engineering Training," R. G. Bellamy, Miss P. J. Wilson and Miss A. R. Chamney, 7 p.m.